

**The Relationship between Performance (Tournament Progression), Daily Stress and Perceived Exertion in Male Participants of Professional Squash Tournaments.**

**by**

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## Acknowledgements

This research is conceptualised in the understanding that to achieve at sport there are many facets that need to be assessed and addressed constantly. For me this concept can be fully understood and is embodied by two quotes.

*“If you always put limits on everything you do, physical or anything else, it will spread into your work and into your life. There are no limits. There are only plateaux’s, and you must not stay there, you must go beyond them.” – Bruce Lee – Martial artist, philosopher and athlete.*

*“Without hard work and discipline it is very difficult to be a top professional.” – Jahangir Kahn (Former world #1 Squash player and record holder for longest winning streak for any athlete in professional sport – 5 years)*

These two quotes represent how I have tried to live and achieve in work, sport as well as academics. Persistence and hard work will often give results that you may never have thought possible.

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## Abbreviations

DALDA	Daily Analysis of Life Demands for Athletes
HREC	Human Research Ethics Committee
NPRS	Numeric Pain Ratings Scale
PSA	Professional Squash Association
RPE	Rated Perceived Exertion
SMS	Short Message Service
UCT	University of Cape Town

## ABSTRACT

### Background

Squash is a popular sport that is played by over 15 million people in 120 countries. Squash is a sport requiring extreme levels of fitness and skill to be proficient at. Squash being a high impact, fast sport that relies on consistency, strength and skill, players often experience stress. This stress is mainly due to the intensity of the matches, but also due to the short duration of the tournaments, which places a lot of pressure on the participants to do well. Stress in sport has been shown to be a critical component in the performance of an individual athlete as well as in team sports. Stress in sport may be categorised as competitive and organisational as well as acute. Not being able to cope with stress may have varied affects for athletes. These include increased anxiety and aggression; decreased enjoyment and self-esteem; and most importantly a decrease in performance expectations and performance difficulties. Furthermore, if an athlete believes he or she cannot resolve the demands of the competitive environment, negative physical and emotions can affect performance. The ability to compete with the presence of different stressors is thus necessary for an athlete to perform at his or her best.

### Aim and objectives

The specific objectives were to establish whether a) Anthropometric and demographic characteristics, b) Daily Stress as measured by the Daily Analysis of Life Demands for Athletes (DALDA) and c) Rate of Perceived Exertion (RPE) as measured by the Borg Scale were associated with competition performance as measured by winning/losing games in national squash tournaments.

## Methods

This study was a longitudinal descriptive analytical study, which aimed to determine whether there was any relationship between the stress experienced by squash players, perceived exertion and performance in squash during competitive play. A sample of convenience was used in that only squash players registered for the tournaments under study were included. Non-probability sampling was thus used, as there was no selection of participants and the entire sample of tournament players was eligible to take part in this study. Twenty-nine participants were recruited and completed the Daily Analysis of Life Demands for Athletes (DALDA) pre-match and RPE scores and an injury survey post-match. Participants who won were re-assessed in the following rounds. Participants who lost their match were not assessed in following rounds due to the knockout nature of tournaments. These surveys were completed using the Magpi survey application (Magpi copyright 2016), which was downloaded for use on a researcher's designated cellular phone.

## Results

There were no significant associations between demographic or anthropometric characteristics and participants' performance. The losing players reported a higher number of stresses in their respective matches. This was most evident in the first and second rounds of the tournaments. In the latter stages of the tournaments, participants reported less symptoms of stress. However, no specific source or symptom of stress was found to be the most related to a poor or positive squash performance. The Borg scale showed the greatest changes related to performance were in round two of tournaments. This was a similar trend as described by the DALDA.

## Conclusion

Daily stress and perceived exertion are present during tournaments and do indeed have a relationship with performance, but only in the first and second rounds of tournaments.

Support to minimise stress should therefore be primarily targeted at the participants who have an intermediate level of skill, rather than tournament winners. Better training modalities, which incorporate the stress management aspects of squash, need to be addressed by the coaches as well as sports medical staff.

## 1 Chapter 1: Introduction and Scope of Thesis

### 1.1 Introduction

Squash has an extensive history and was originally started in the late 1800s (1). It has, over the years, developed and grown to be a sport that is played by over 15 million people in 120 countries (2). Squash is an open skill sport that requires high levels of fitness to perform well. Oxygen consumption has been shown to be at 57% and heart rate at 72% of maximum values during play (1,3,4). Girard et al (2007) reported even higher values with squash players achieving 86% and 92% of their maximum oxygen consumption and maximum heart rate respectively during play (3). These high values may be due to the stress of competition as well as the increase in ambient air temperature on court (1). Due to the non-uniform pattern of play during a match, there needs to be sound judgment and correct stroke selection during the high pace of play (3,5,6). To maintain this high level of skill and consistency during play, a certain level of control over one's stress on and off the court is required (7). Stress may therefore have an impact on the physiological response to playing, as well as on the overall performance of the player (8–11).

Stress in sport has been shown to be a critical component in the performance of an individual athlete as well as in team sports (12–16). Stress in sport may be categorised as competitive and organisational as well as acute (8,13,14,17–21). The inability to cope with stress may have a wide variety of associated effects on athletes. These include increased anxiety and aggression; decreased enjoyment and self-esteem; and most importantly a decrease in performance expectations and performance difficulties (14,16,19–24). Furthermore if an athlete believes he or she cannot resolve the demands of the competitive environment they are likely to experience those same negative emotions of anxiety and aggression as well as negative physical outcomes such as tension in muscles which may influence performance (12–14,20–23,25–29). Stress has a dynamic relationship with the athlete and the athlete's environment. The ability to appraise and then react appropriately to a given competition stress is essential for an athlete to perform at his or her best (12–15).

Assessing stress in athletes is challenging due to the variability of stress and more importantly the variability in how athletes experience a stressor (15,21,26,30). This is seen in athletes that experience a particular stressor and consequently have a high level of negative emotions related to that stressor. Another athlete might have the same stressor and actually have a positive outcome or emotion (12–14,16,26).

The most common self-assessment tools used by athletes to assess stress are the Profile of Moods States (POMS), and the Daily Analysis of Life Demands for Athletes (DALDA) (11,27,31–33). The POMS has been a popular tool used by researchers, but has a drawback of not being sports activity specific. This however does not seem to impact the results as the athletes who use the tool adapt readily when using it (34). The DALDA has been used by athletes and coaches alike to assess whether an athlete is being over trained (34). The value lies in the fact that it is specific to sporting activity and can be administered both pre-activity and post-activity. The DALDA is a self-reporting tool that has two parts which assess the athlete's sources of stress in part A and the symptoms of stress in part B (34–36). The DALDA is also best used on a daily basis, but has shown efficacy with every other day or once a week (34–36). The DALDA is reportedly effective, valid and reliable in assessing whether an athlete is affected by sport-related or non-sport related stressors that may be detrimental to performance (18,19,37).

Perceived exertion is a secondary aspect that needs to be addressed, as it is closely linked to how stress is appraised by the athlete. This is seen in athletes who get tight or tense when stress is present (8,12–14,26,38). Perceived exertion is measured by self-assessment as with the DALDA and measures an athlete's appraisal of his or her level of exertion or effort during a particular activity (39–42). It is suggested that exertion and fatigue are closely related and may be regarded as emotional rather than physical manifestations (43). This therefore ties in with the stress aspects of sport, which often elicits an emotional response as well as physical ones during competitive play (14,15,19–21,23,24,26,30,31,44).

Based on the above discussion, the following research questions need to be answered. Is there a relationship between the stress experienced by squash players on a daily basis, perceived exertion and performance in squash during competitive play?



Does winning or losing matches influence the experience of stress and exertion similarly? Does the level of stress and exertion change over the rounds of the tournament?

It has been shown that within all sports there are differing levels of skill as well as fitness in different players. Squash player differences can be delineated according to professional players/grade A, grade B, and grade C respectively (1), which can be paralleled to first, second and third league in the South African context (1,3,45). This study will concentrate on the players who have the higher level of skill and, those who take part in the first league competitions.

## 1.2 Aims and Objectives

### 1.2.1 Aim

The primary aim of this study was to assess whether there was a relationship between performance, daily stress and perceived exertion in competitive squash players during a squash tournament.

### 1.2.2 Specific Objectives

To determine whether Performance is associated with:

- *Anthropometric and demographic data*
- *Daily stress as measured by the DALDA*
- *Perceived exertion as measured by the Borg scale*

## 1.3 Significance of Study

Competitive squash players are always striving to improve their performance.

A better understanding of the relationship between stress levels and performance will assist them and their coaches to recognize the sources of stress in the players' lives so that it can be better managed.

If a relationship between stress and perceived rate of exertion were found, it would further highlight the need to manage stress during competitions. The study has further significance in that if the assessment tools used are easy to use they could be utilized by all squash players and coaches to assess any changes that could affect their performance outcome and help to develop the sports methodologies.

#### 1.4 Plan of Thesis

A literature review on topics related to squash, squash performance stress as well as instrumentation and measurement techniques is presented in Chapter 2. Chapter 3 describes the descriptive cohort study designed to investigate the relationship between performance, daily stress and RPE. Chapter 4 concludes the thesis by presenting the conclusions and recommendations from the research study.

## 2 Chapter 2: Literature Review

### 2.1 Introduction

The focus of this study was on the inter-relatedness of stress, perceived exertion, injury and performance. The review therefore starts with a description and demands of squash and explores the epidemiology of injury in squash players. The overall performance of a squash player would appear to be determined by injury, rate of perceived exertion (RPE) and stress and these will be discussed. This concept of performance can potentially be condensed into one gross measure of performance i.e. tournament progression, as for a player to progress through the rounds of tournaments, the ability to adapt and cope with mental and physical stressors is required.

The role and impact of stress is explored and the RPE during games is discussed. Most notably there is a lack of information and data related to squash players ability to cope with stress and its associated effects on the squash player. Many racquet sports, e.g. tennis, badminton, table tennis, have looked at various aspects of stress, which will be used to compare with findings related to squash. Understanding how the factors of training, conditioning, perceived exertion and performance interact with stress presents a unique and yet understudied area in squash athletes.

Literature on squash and the related topics of this review were sourced using the search engines Google Scholar, PubMed and Ebscohost. The following search terms in various combinations were used: Squash injuries, rate of perceived exertion, perceived exertion in sport, injury incidence in squash, physiology of squash, squash training and periodisation, stress in sport, mood and sporting performance, coping strategies of athletes, performance outcomes in squash, Daily Analysis of Life Demands for Athletes (DALDA). It should be noted that due to the significant lack of squash specific literature much of the information that has been found is related to racquet sports in general, with few articles that examine squash exclusively.

## 2.2 The Sport of Squash

Squash has a prestigious history extending from the late 1800s (1,2). It has developed and grown to be a sport that is popular for approximately 15 million people worldwide (1,2,46). It has in recent years introduced innovations to the scoring methods and to technological improvements in racquets and balls as well as courts. Competitive squash in its current form requires extremely high levels of speed, explosive power, cardiovascular endurance, skill and mental agility in comparison to other racquet sports, (1,4,45,47,48).

### 2.2.1 Physical Demands of Squash

Squash rallies have been noted to be on average 10 to 20 seconds in length with the recovery period between points about seven to eight seconds (3,49). The reverse was found in tennis where the rally length was approximately seven to ten seconds and recovery between points was 15 to 20 seconds (49). This indicates that, squash players are effectively playing 50% to 70% more than tennis players per rally (1,3,49). Comparing the game length of professional/grade A players with lower grade players indicates that the higher the level and skill of the players, the longer the games takes (1). The range is 11.6 minutes to 12.3 minutes per game for the professional and grade A players compared to a 6.2 minutes to 8.1 minutes per game in the lower ranks (1). Therefore, an average match could take between 30 minutes and 90 minutes for a best of five games per match (1,50). This, in addition to playing at high intensity levels makes this sport exceptionally physical and challenging (45). Squash is clearly a physically taxing sport that requires significant endurance skill and strength and it may be difficult for players to maintain their composure and stress levels within manageable parameters (3,45,49).

As discussed above, squash is an opened skilled sport which makes it challenging both physically and mentally (12,27,29,51–55). To play squash at a reasonably high level a squash player needs cardiovascular fitness as well as skill (1,3,4,49,50,56–58). The skill aspects are related to technique and the mental ability to apply the different techniques appropriately during a match. If players do not have an adequate level of fitness, their technique will deteriorate and thus their performance is likely to drop (57,59,60).

Poor performance and technique breakdown can lead to the squash player starting to feel stress and in turn, the stress can result in further deterioration. The converse it also true in that if stress is present, then there is the potential for a poor performance and deterioration of technique. This is then linked to the need to work harder to achieve and this may then increase the players' perceived exertion (8,27,61,62). Adequate training may therefore be a means to offset the feeling of stress as well as perceived exertion before and during a match, depending on whether the players' technical ability remains of a high quality. Correct appraisal of the stress presenting to a squash player is also very important in assisting the player to cope with such high levels of stress. (12–14,16,20,21,25,26,30,63).

### 2.2.2 Performance in Squash

For the purposes of this study, performance was represented by the single concept of progression through a tournament. It is acknowledged that other aspects could be monitored, such as technique or game strategizing but an examination of these is outside of the scope of this study. The mental aspect of squash will be covered in more detail later in this review.

A five set match may last up to three hours in duration, which places extreme physical demands on the players as high forces are required to be generated for movement and rapid changes of direction as well as for hitting force. Furthermore, quick reactions and a steady eye are also important components that need to be addressed to be adequately fit to participate in squash (47).

The physical requirements of squash have been described in the literature (1,45,47,58,64). Squash is a sport that requires both aerobic and anaerobic fitness. The levels of fitness needed are described by means of maximum oxygen consumption and heart rate. Oxygen consumption during play was shown to be 57% of the maximum oxygen consumption ( $VO_{2max}$ ), and heart rate was at 72% of maximum heart rate ( $HR_{max}$ ) during play (1,64). The mean value for  $VO_{2max}$  of the elite squash player is between (56 and 64 ml/kg/min). A study comparing  $VO_{2max}$  values of squash players from different countries showed relatively comparable  $VO_{2max}$  values in Asian players (61ml/kg/min), South African players (59.5ml/kg/min), Canadian players (56.0 ml/kg/min) and Australian players (57.8 ml/kg/min) respectively (3,45).

It should also be noted that these squash player values are not expected to reach the values generated by endurance sport athletes such as cycling who achieve much higher values as described by the Hong Kong 1988 Olympic cycling teams mean  $\text{VO}_2$  max of 72.1 ml/kg/min (45). This was suggested to be due to the fact that the stress of competition as well as the increase in ambient air temperature on court allows for an increase of heart rate but does not affect the  $\text{VO}_{2\text{max}}$  of the player (1). Girard (2007) also concluded that squash was indeed an aerobic as well as an anaerobic activity, which described squash players achieving 86% and 92% of their  $\text{VO}_{2\text{max}}$  and  $\text{HR}_{\text{max}}$  respectively during play (3). The mean HR of squash players from Germany (195 bpm), Asia (190 bpm), and South Africa (184 bpm) are all within a relatively close range (45). The high levels may be attributed to the change in the scoring system from a nine point system where one could only score points when serving, to Point A Rally (PAR) scoring system first to 15 points and more recently to eleven. In addition, the lowering of the tin, i.e. the area on the front wall in which a player is not allowed to hit the ball, from 48.3cm to 43.2cm, has made the court feel longer by forcing players to move further up the court to fetch drop shots and short kills thus increasing the overall intensity of the game significantly (65).

### 2.2.3 Measurement of Performance

In competitive sport, there is pressure for athletes to perform consistently and squash is no different. Performance in squash has been generally defined according to completion of tasks and the consistency in execution of those tasks using a notational method of describing different strokes, movement patterns and their consistency (66–68). Various court situations were addressed and whether the stroke outcome was a winner or an error. These methods attempt to model a particular pattern of play and correlate it to performing adequately (5,55,56,67,69,70). Other means of testing performance of squash players have been to observe the physical and physiological state of players such as heart rate,  $\text{VO}_{2\text{max}}$ , strength and power values (56,57). The most obvious measure of performance, however, is the level of competitive performance. Sporting performance as a whole is a variable that is dependent on what the sporting outcomes are for the sport in question. In most instances, performance in opened skilled sports is seen as either winning or losing a match (29,52,61,66,71).

With squash being an opened skill sporting activity it makes sense to still look at performance as a win/loss variable as the primary goal in open skill sports is to beat your opponent and thus progress through to the next round of the tournament one is participating in (29,71,72). This is a broad means of assessing performance as a player may have played exceptionally well and still lost the match. For the purposes of this review we will look at tournament progression as a means of overall squash performance as it incorporates all the aspects of coping with stress and maintaining technique through a tournament. A squash player's pre-competition or training stress may therefore show why the player may have lost even though playing well according to conventional performance rating systems. Other means of assessing performance for squash specifically could be time spent on court during a match. This is applicable as the longer a player stays on court the higher the likelihood of fatiguing due to the high intensity of the sport (3). The pre-competition mood has been documented to play a role in the performance of athletes (31). An athlete needs to overcome a myriad of obstacles to perform, none so obvious as stress (73).

#### 2.2.4 Squash Tournament Structure and Research Setting

As there are only four Professional Squash Association (PSA) tournaments in South Africa, it is often difficult to get data that are statistically pertinent to the development of squash. Competitions and tournaments are normally structured in either a 16 or 32 participant draw. Tournaments can be registered as open or as closed tournaments. Open tournaments are open to all eligible and registered squash players across the globe. The prize money determines tournament tiers. Generally the lowest tier of tournament is a Challenger 5 tournament, meaning that the total prize money is \$5,000, which progressively goes up to gold standard of up to \$100,000 and above. The winnings are split amongst the participating players according to a defined criteria stipulated by PSA and WISPA. As one goes up in tier the quality of squash player goes up. The more accomplished players participate mainly in the 15 Challengers and above (74).

## 2.3 Training

The intensity of the game of squash highlights the need for appropriate training modalities that are needed to achieve at the sport. A rigorous training regime is necessary and needs to incorporate the important aspects of power, speed and endurance (6,47,58,75–77). It is not uncommon for elite squash players to train three hours a day, for six days a week and eleven months of the year, with an average of 70 matches played per season for a professional player (45). Training and participating in squash requires athletes to use full body movements (64,78,79). Quick reactions are a vital component of high level participation in squash (47,80). Thus training needs to incorporate full body as well as specific mental and hand eye co-ordination activities (6,45,78–80).

### 2.3.1 Aspects of training

Training for squash players can be streamed into flexibility and strength, cardiovascular, squash-specific skill (court movement and technical skill to hit ball correctly) and mental training, all of which relate to performance (45,47,58,64,75,79–83). As the focus of this study is on stress and its effect on performance, the mental training required will be discussed here.

Mental training is an important aspect of squash, which needs to be addressed on a regular basis. Psychological skills training incorporate five areas, which need to be covered. These areas are: assessment, education, implementation, problem solving and evaluation (56,64,80). Several mental training skills have shown to be beneficial for athletes and should be incorporated into squash players training regimes. These skills include relaxation techniques, visualisation, video sessions and on-court practise incorporating certain skills and then feedback (38,56).

The concept of mental toughness becomes an important factor to address. This is considered the ability to overcome stressful situations during match play or training (47,57,84). Mental toughness is defined as *“having the natural or developed psychological edge that enables you to generally, cope better than your opponents with the many demands (competition, training, lifestyle) that sport places on a performer”* (84).



“Inoculating” a squash player to cope with the pressures and stresses of squash has been proposed in the literature and has shown to be of use to improve overall squash performance (38). The techniques used include those that have been mentioned, but also include immersing the player in an environment of excessive physical and mental stress to allow the player to learn how to overcome or cope with the stress. Athletes have used various other strategies to cope with stressors. These include cognitive strategies, cue awareness, learning about opponents and practice (15,18,19,85). This type of inoculation takes place in three phases (38).

Phase one incorporates introducing definitions and understanding of what stress is and how it affects the arousal state to the player (38). Different arousal states have been addressed in other sporting codes and appear to be an important factor when relating them to performance (18,19,33,37). Thus the alertness of an athlete is being associated with either an increased or decreased physiological state related to physiological aspects such as heart rate, adrenalin, tension, sweating, increased breathing pattern and many other physiological changes, have been shown to affect athletes mental state and performance (23,25). The second phase is the rehearsal stage where the player is taught various coping skills, whether breathing, visualisation or other effective skills (38). The third phase is the application phase, where the players are asked to call upon their coping skills training and utilise them in specific stressful squash scenarios (38). Initially the stress will be introduced at a low to moderate level, and will then be incrementally increased to improve the level of coping the player can attain (38).

### 2.3.2 Recovery

Recovery describes the ability of an athlete is able to adapt to training and competition workloads (86). Adaptations to training and competition can be either physical or psychological (86). Ineffective assessment and management of fatigue associated with training workload and competition is a potential cause for the condition of overtraining and is also related to overtraining syndrome (87). A differentiation of chronic fatigue and overtraining syndrome must be made with the definitions of each being as follows:

*“The overtraining syndrome is a condition of fatigue and underperformance, often associated with frequent infections and depression which occurs following hard training and competition.*

*The symptoms do not resolve despite two weeks of adequate rest, and there is no other identifiable medical cause. Chronic fatigue syndrome being defined as the above symptoms presenting for over a 6 month period” (87).*

Recovery techniques or strategies aim to reduce fatigue post-training or competition (49,58,81,86). The most important areas that need to be addressed when considering recovery strategies are as follows: a) work/rest ratios; b) nutrition; c) physical therapies; d) psychological skills (81). Rest can be either passive or active rest, both of which need to be utilised as using only one will have limited benefit (33,37,55,86,88). Passive rest includes activities such as sleep, which is considered to be one of the most important activities. Other such activities are meditation and reading (86). Active rest activities for athletes can effect various systems the most commonly addressed systems are the physiological, musculoskeletal and psychological systems (86). Activities such as light walking or cycling, swimming, cross training (low intensity), visualisation, light exercises and stretching are all used as active rest. It should be mentioned that flexibility of squash players is a vital component for players to play optimally as well as for recovery. Stretching is generally incorporated into all phases of training (83,89,90). However, the literature in general does state that regular stretching does not conclusively show any significant benefit as does not stretching (89–92). Warming up correctly and appropriately does show some benefit in allowing for sprinting activities which squash has components of (9,83,89,90). The DALDA is an effective tool by which an athlete can monitor their training and therefore assess whether they are overtraining or over-reaching (10,11,33,37). This is useful for timeous interventions to prevent the negative impact of training and competition (93).

## 2.4 Squash Injuries

As injuries may be either a result of excess stress and intensity of activity or a cause of excess stress, squash injuries are included in this review (12,13,62,94,95).

It is noted that in general there is very little literature available on squash-related injuries. Information is more readily available for tennis and badminton and very little in table tennis (56). Population studies in Australia and UK reported that squash-related injuries made up only 2% of the overall number of all sports and recreation injuries.

However, squash had the highest number of severe injuries compared to other more high risk/impact sports such as rugby and football (2). It was also noted in the UK that the incidence of injury amongst squash players was 5 injuries per 1000 playing sessions (2). The severity of the injuries studied in the UK showed that 47% of the injuries were severe in nature (2). The Squash injuries can be differentiated into four major categories. These being musculoskeletal injury which accounted for 64% to 91% of all squash-related injuries; head and eye injury which accounted for 5.2-33.3% of injuries per 100 000 playing sessions; heat-related illnesses; and cardiac injury, which is a likely cause of death related to participating in squash and contributed to a mortality rate of five deaths per year (2).

Specific injury patterns are present for beginner and more elite players. The literature has shown that injuries are most common in the upper extremities of beginner and low-level players. In contrast, the lower extremities of the body of more accomplished players are more prone to injury and comprise of sprains and strains (2,96–98). Common areas of injury for both groups are the knee, lower lumbar region, lower limb musculature and ankle (1,2,46,96). Other areas prone to injury are the head, eyes and the upper limbs. The eye is most susceptible to injury due to the size of the ball used in squash and also due to the close proximity of the players to each other during play (2,46,96,99). Upper limb injuries usually affect the shoulder complex due to player collisions into the wall while compensating for poor movement patterns (2,97). However, it has been shown that the elbow was the most common upper limb injury and usually related to overuse (46). In the less accomplished players, the acute injury pattern is found to be in the trunk, upper limb and lower limb (2). For the elite player, however, it is suggested that overuse injuries are most common especially in the lower extremities (2). It should also be noted that injuries related to squash are most prevalent in participants that are over 25 years old which is different to the general pattern found in other racquet sports such as badminton and tennis (96).

In the South African context, a high incidence of thigh, shoulder and lower back injury was found in adolescents residing in the Western Cape (2,46,100).

This similar pattern is found in other studies, however there is currently no literature describing the pattern of injury in the adult squash population in the Western Cape and in South Africa.

Sporting injuries in general have been related to various other aspects of participation. This includes the level at which a sport is being played. It has been noted by Murphy (2003) that there is an increase of injury of athletes that participate in competitions as well as high intensity training (101). This was seen in variety of sports e.g. American football, football, handball, basketball, ice hockey and volleyball (101). Basketball has similar demands to squash, given the stop-start nature of the game as well as the constant change of direction and change of speed on court. Measured intensity of play using either the rate of perceived exertion or modified rate of perceived exertion scale had values registering at the high end of the scale, associated with a greater incidence of injury (93,102). This increase in intensity in competition and training is often associated with the stress of the desire to win and with an increase of aggression as skill level increases risk (101). Stress has been shown to be associated with an increase in sporting injury (62,94,103,104) and stress of a personal nature as well as at a competition level has been shown to affect the incidence of injury (12,94). Stress can affect a players ability to maintain an effective technique and thus increases the risk of injury (103,104).

## 2.5 Fatigue and Perceived Exertion

Fatigue is a complex entity and not easily described. It encompasses many facets of sporting ability, most notably a decrease in force production of muscles utilised in performing a sporting activity (49,86). Other aspects of fatigue include the cardiovascular as well as psychological aspects (49). Fatigue has been noted by Girard et al (2009), to be task specific. In relation to squash, fatigue presents in a player as the duration and intensity of the physical activity increases (49). As perceived exertion increases there is a correlated increase in fatigue i.e. decreased force production (49). When comparing the  $HR_{max}$ ,  $VO_{2max}$ , and lactate produced in squash players compared to tennis, table-tennis and badminton, squash consistently scores higher (3,49). This is due to the high impact and high velocity movements required on a squash court while competing.

However, more recent literature suggests that there is a central nervous system override, which regulates all sporting activity and performance through motor unit recruitment (43).

This central governor model attempts to prevent 'catastrophic system failure' by adjusting motor unit recruitment (43,49). The central governor model thus suggests that the more elite sports participants are able to override the feeling of fatigue to a degree (43,49). With higher intensity activity, fatigue onset presents faster and the deterioration of the participants performance becomes evident (49). This is representative of many high intensity sports such as badminton, tennis and squash (3,49,61,105). Physical fatigue is most easily reported using the RPE scale (105,106).

### 2.5.1 Measurement of Perceived Exertion

The RPE scale is a commonly used scale for sports-related research. It is a self-administered scale and has been shown to be both valid and reliable in scientific research as a means of testing activity intensity (40–42,107). The rate of perceived exertion is noted to be the ability to detect and respond to physical sensations produced by physiological changes that arise due to exercise (41). It can also be utilised to assess intensity of the exercise being tested (40). The validity and reliability of RPE has been established for various sporting codes as well as on a gender based and age based criteria (39–42,107). The reliability being how consistent rate of perceived exertion is in recording the same value for the same exercise by different people and the validity being how closely RPE can be transferred to the physiological and exercise intensity values being tested. The rate of perceived exertion is used to give an indication of exercise effort according to recognised physiological factors such as  $VO_{2max}$  and HR (40–42,107). According to Day et al (2004) the Interclass correlation coefficient (ICC) was 0.88 with a 95% confidence interval. The Coefficient of Variation (CV) was used by Day et al (2004) and tests reliability of RPE and was found to be 14.5% (40).

Similarly it was found in Chen et al (2002) that the intra-reliability coefficient was found to be 0.94 (107). Using regression analyses, Herman et al (2006) found that RPE was a reliable tool related to  $\%VO_{2peak}$ ,  $\%HR_{peak}$ , and  $\%HR_{Reserve}$  and was 0.96, 0.93 and 0.93 respectively.

It has been shown using the Borg scale that during competitive sporting activity (e.g. a squash match) an athlete will experience varying levels of intensity during a match and possibly during a game (82). Perceived exertion appears to be associated with injury incidence in that with an increased level of exertion experienced, there seems to be an increased rate of injury (93). This is most evident in a non-competitive region of the athletes training but also is present in a competitive zone of a players training (93). Competitive zone injury incidence has been established in rugby players as well as in various other competitive sports (101,102,108). Although there is the physical impact to take into account in regards to rugby injury, the idea of increased injury incidence has significantly been correlated with increased intensity of training and match play (102). It has also been noted that players exertion increased as they were able to adjust their intensity of play to cope with the increased physical demands and environmental factors (3,4,18,20,49,56,64). It should also be noted that with an increased intensity of activity there is also an increased risk of mental exhaustion which can affect the risk of injury as the athlete may start losing concentration as well as control over their technique (16,18,21,93,94,109).

## 2.6 Stress

Stress can be closely related to the emotion or mood of the athlete (12–14,16,19,21,23–25,27,31,44,95,110). Thus the perception of stress before or during play can change rapidly for any athlete depending on the context in which the stress presents. A distinction between stressor and stress needs to be made. Stressors can be any number of items. The most common include pain, fear, lack of confidence, psychological demands, coach stress, demands of playing the sport (training), injury, work, academic problems, finances, audience interference, referee decisions and relationships (12,18,19,23,25,44,84,87,111). Stress is the perception of the stressor by the athlete and the ability to cope with the stressor (12–14,18,19,21,44). Stressors can vary from day to day and the ability of the athlete to cope with them can also change (44). In the context of squash players, due to the uniqueness of the sport where players are in close proximity to their opponent the stressors and experience of stress is very evident.

Being in an enclosed space with very close interactions with ones opponent adds a dimension to the experience of stress, which can also heighten the experience of other internal and external stressors (16,17,21,23,25,35,38,44,112).

The focus behind training is to be able to compete at ones sport without having to succumb to stress (8,13,17,21,37,113,114). It should be noted that stress is not only present from the activities related to the sport but also due to other external factors such as home life and relationships (12–15,18,20,25,30,31,44,93,113). All aspects of stress need to be addressed and factored into the athlete's ability to perform at his or her best while playing a tournament or training (23,25,38,84,105).

### 2.6.1 Measurement of Stress

There are various means by which stress or mood can be assessed. There is the Profile of Moods Scale (POMS), which has been widely used to assess stress in various sporting codes and there is also the Daily Analysis of Life Demands for Athletes (DALDA) (31,34,110,114). The POMS, has been shown to be predictive of cross-country running times and in several other sporting codes as a means to assess the overall outcome of sports performance (27,31). This was most evident in sports which were individual in nature, of short duration and required open skills to participate in the sport (10,27,31,37,87,115,116). This finding was attributed to the fact that for long duration sports, the mood of the athlete was likely to fluctuate naturally due to length of time required to perform. For the open skilled sports, it was suggested that an appropriate pre-competition mood was required to cope with a changing environment (5,27,52,55,87,115,117). The POMS form unfortunately has logistical drawbacks, which do not allow for easy administration and interpretation of results (31,116). The POMS was originally developed in 1971 and had 65 items which required answering, and has been adapted and shortened over the years to a 30 item version (116,118). A disadvantage of the POMS is the fact that it was originally meant for use in a clinical setting and not necessarily for an active or exercise population (116).

There are also five subscale measurements in the POMS which relate to negative mood characteristics and which are not easily conceptualised (116). Furthermore the time considerations in taking the POMS become significant when doing repeat assessments (116).

The DALDA may be a more appropriate tool to use as it too has been shown to be both valid and reliable in assessing an athletes stress/mood levels (114). The validity of the DALDA was established through a content validity process whereby a pool of 13 stressors and 44 symptoms were developed (63). The resultant items used in the DALDA represented situations and behaviour that is commonly seen in elite athletes (35,36,63). The reliability of the DALDA was established using a squad of swimmers. These participants were chosen for the reason that environmental and lifestyle stress factors could be easily controlled (35,36,63). Testing of the participants was done multiple times and in order to control the subjects they were given a specific planned lifestyle for three days before being tested (35,36,63). Coaches were also required to perform the same training regime. The reliability criteria for the DALDA was stated that if a stress source or symptom was not scored exactly the same in four of the five testing occasions by eighty percent of the participants, then that item would be removed from the overall survey (35,36,63). Thus the current form of the DALDA was created with nine sources of stress and twenty five symptoms of stress (35,63). The DALDA has various functions and is able to monitor the following: training response, daily training, excessive training sessions, training sessions that are too easy, overtraining, travel disruptions, outside stresses and peaking (35).



## 2.7 The DALDA

Having described the various tools available to test stress, more detail on the DALDA is provided here. There are two parts to the DALDA assessment. Part A is a 9-part section assessing an athlete's source of stress and part B assesses the athlete's symptoms of stress (34,114). The sources of stress include items such as diet and home-life. The symptoms are items such as muscle pains, boredom, irritability etc. Although the DALDA is best utilised and administered on a daily basis it is still able to give valid and reliable information when used once a week (33). The stress of daily life has been shown to affect an athletes training and match play adversely depending on how much stress is present, whether training related or other aspects of life (11,36). The DALDA is an important means by which one can assess an athlete's daily stress. This is shown in various studies looking at athletic stress and ability to cope (11,33,34,37).

## 2.8 Interaction of Stress and Perceived Exertion with Performance

Stress has been shown to have a significant effect on an athletes overall performance (28,62,73,119) and a decrease in shot quality and correct shot selection have been described with increasing stress levels (23,25,62). Furthermore, movement patterns can be disrupted thus decreasing the overall sporting performance (25,62). This is perhaps not as evident in sporting codes where there is minimal movement and technical skills that need to be combined to perform adequately. Sports such as weight lifting have many technical aspects, however the athlete is not required to run into position and then perform a clean and jerk movement in a fraction of a second (120). Thus the stresses that are experienced by racquet sport athletes are unique. Due to the variability in how an athlete assesses and perceives stress and activity intensity the overall performance can vary. When performance is decreased due to stress there is a sense by the athlete that there is an increased level of exertion that takes place (25,62). Alternatively, if an athlete is experiencing an increase in intensity in activity he or she can start feeling mentally as well as physically exhausted thus leading to a decrease in concentration and a further decrease in control of body movements and therefore an increased risk to injury (62).

However, it should be noted that in competitive and elite athletes the risk of injury increases due to the fact that they are willing to push their bodies to severe limits to achieve their physical goals (101,108).

## 2.9 Conclusion to the Literature Review

Squash is a physically and mentally demanding game, which requires high levels of training. Squash injuries are common and can be related to fatigue and stress levels. The Borg Scale of RPE has been used extensively to monitor perceived exertion in athletes and the DALDA is a relatively new instrument developed specifically to monitor stress in athletes. There are techniques, such as “inoculation” against stress that could be used during training, to assist players to manage their stress, once it has been identified. Based on this review, there is a need to explore the interaction of stress, fatigue and performance (11,43,87).

## 3 Chapter 3: Methodology

### 3.1 Introduction

A longitudinal descriptive analytical study was used to investigate the relationship between stress, perceived exertion and progression in four professional level squash tournaments in South Africa. It was suggested that players would report an increased perception of stress as a competition progresses (94,109,121). In addition, there would be a significant positive correlation between stress levels and levels of perceived exertion (42,56,105–107,122). Finally, it was thought that the most successful players (i.e. those who progressed to the following rounds), would report the least stress and exertion levels during play at lower levels of the competition.

### 3.2 Methods

#### 3.2.1 Research Design and Recruitment

Four squash tournaments were used for data collection, two of which were Professional Squash Association (PSA) tournaments (i.e. The UCT Keith Grainger Memorial Tournament and the Western Province Open). The remaining two tournaments were the South African Nationals Tournament and Western Province Closed held in Gauteng and in Cape Town respectively. The main draws of each tournament consisted primarily of registered PSA players who have entered the tournament via the PSA website. Non-PSA players who entered the tournament were automatically placed in the qualifying rounds. All the participating players were first league and professional level.

All data collection took place at the designated squash center where participants would fill in their respective surveys pre and post-match play.

#### 3.2.2 Participants

##### 3.2.2.1 Inclusion Criteria

A sample of convenience was used in that only squash players registered for the tournaments in question were included.

All male players between the ages of 18-50 registered for the tournaments were invited to participate. Female squash players were excluded on the basis of hormonal fluctuations present during the menstrual cycle, which have been shown to influence a female athletes performance, and could therefore influence the results (27,28). In addition, the number of female squash players is relatively small and not large enough to allow for generalization of the results.

#### 3.2.2.2 Sample Size

The sample size was dependent on the draw of the tournament. All four of the tournaments had a 32-man draw, yielding 128 entries for the main draws of the tournaments. However, the number of entries did not equal the number of possible participants as several players entered for two or more tournaments.

Only one set of data was analysed from each participant, implying that even if a participant had taken part in all four tournaments, only a single data set would be entered. This data set was the most complete, i.e. had the greatest number of entries, and was therefore the data set of the tournament in which the participant had progressed as far as possible.

#### 3.2.3 Measurement Instruments

A self-designed questionnaire was developed to gather demographic, anthropometric and medical data from the participants. The standardized instruments used in this study were the Daily Analysis of Life Demands for Athletes (DALDA) and the Rate of Perceived Exertion (RPE). The RPE and DALDA have both been described in the literature as being valid and reliable.

##### 3.2.3.1 Modified Medical History and Injury Incidence Surveys

The first survey is a medical history (APPENDIX E: Medical History) and injury survey (APPENDIX F: Injury Survey). The medical history form was based on the standard anthropometric questions found in all medical history forms, with the addition of specific squash-related questions which were of interest to this study, e.g. injury history, and years playing squash. Similarly, the injury incidence survey was based on an already existing standard survey which can be found on the website of Sports Medicine Australia (sma.org.au).

The injury survey form was then further adapted for use on the Magpi platform (123). This was completed when players registered for the tournament and after completing a consent form. The Modified Medical History survey also included anthropometric data, which included height (cm), weight (kg) and a previous injury section, which was self-reported. Self-reported data however needs to be looked at cautiously especially in convenience sampling (124–127). In general men overestimate their height whereas women tend to under-report their weight especially as they increase in age (124,126). Due to the lack of literature related to self-reported BMI in the athletic population it is unclear whether there would be the same discrepancy. However it has been shown by Jacobson et al (2001) that there was no statistical difference between self-reported and measured BMI and due to this it was felt that any discrepancy was not sufficient to adversely affect the overall outcome of BMI in this study (127). The second survey is a detailed injury surveillance survey, which was completed should an injury have taken place during the tournament and was administered via the Magpi mobile application.

#### 3.2.3.2 Daily Analysis of Life Demands for Athletes (DALDA)

This is a self-assessment tool, which has been demonstrated to be valid and reliable (17,29,30). The DALDA's validity was established using content validity protocol after a pool of 13 stressors and 44 symptoms was developed. The reliability of the DALDA used test-retest procedures of 52 athletes who were tested repeatedly on 5 separate occasions, a minimum of 14 days apart (63). The DALDA has various functions and is able to monitor the following: Training response, daily training, excessive training sessions, training sessions that are too easy, overtraining, travel disruptions, outside stresses and peaking. There are two parts to this assessment. Part A is a 9-part section assessing an athlete's sources of stress and part B assesses the athlete's symptoms of stress. For the purposes of this study focus will be on using the DALDA as a means of assessing the athletes peak performance and stress (63). (APPENDIX G: Daily Analysis of Life Demands for Athletes (DALDA))

### 3.2.3.3 Rate of Perceived Exertion (RPE) – Borg Scale

The RPE is a self-administered assessment, which assesses the participants' own level of exertion during an activity. The scale starts from 6 – 20, where 6 is considered to be “*no exertion at all*” and 20 is an indication of “*maximal exertion*”. The participant will then choose the number, which closest relates to their level of exertion post activity.

The Borg scale has been shown to be both valid and reliable as a means of assessing a participant's level of exertion in various sporting codes, but has not been specifically assessed for reliability and validity in squash players and therefore does have some limitations (APPENDIX H: Rated Perceived Exertion (RPE) – Borg Scale) (32–35). The current validity coefficient has been shown to be quite high in swimmers (0.78-0.84), but lower in other sporting codes (107). The reliability of the Borg scale has been shown to be 0.94 in some studies (107).

### 3.2.3.4 Magpi Survey Application

The Magpi survey application is a service provided to all industries to collect data (home.magpi.com). This survey application can be used by either using a computer by sending out emails with the surveys to the respondents or by using a cellular phone with the application already downloaded for use. For the purposes of this study, the Magpi survey application was downloaded onto one cellular phone, which had all the surveys loaded and which all the respondents used to fill in their respective surveys. Surveys were generated online by the researcher. It has a very easy to use format, which allowed for respondents complete surveys online or via mobile phone. The DALDA, RPE, injury incidence and match duration surveys were administered to the participants using this mobile application.

### 3.2.4 Procedure

All the tournament directors of the respective tournaments were requested by e-mail to allow the use of their tournament for data collection. This was done a month prior to the start of the respective tournaments. All tournament directors were sent all the relevant documentation and letters pertaining to the study. The tournament directors were requested to forward the information package to all potential respondents of the tournaments.

On arrival for tournament registration, all participants were required to complete an informed consent form prior to being included in this study as can be seen in (APPENDIX C: Information Letter) and (APPENDIX D: Consent Form) respectively. All important and relevant information was included again in an information letter, which was attached to the consent form detailing all aspects of the study including risks and benefits as well as right to withdraw at any time during the testing phase.

Respondents were asked to fill out the respective surveys on the researchers cellular application, at least one hour prior to their designated match and immediately after their match. This was done in a designated area at the respective squash venues while being supervised by the researchers, to assist with any questions regarding the survey.

### 3.2.5 Statistical Analyses

Statistica 12 and SPSS statistics 22 programmes were used to generate statistical analysis on the data collected. A level of 0.05 was set for statistical significance.

The data that were collected were mainly categorical and ordinal in nature and in most cases non-parametric tests were used. Descriptive statistics were used to describe the sample.

The Chi Squared test was used to compare observed frequencies with expected frequencies of the variables of interest in our study. The Chi-square illustrates whether there are any associations between chosen variables. However, the test does not give any indication of the strength or nature of that association should one be present. The Mann-Whitney U test determines if two samples come from the same population. Statistically the Mann-Whitney U test uses a null hypothesis to assert whether populations of two samples have the same probability distribution (36). The Wilcoxon Signed rank test was used to analyze data that has repeated measures. The goal was to determine whether participants changed significantly across occasions. Friedman's ANOVA was used to determine if there was a difference in ranking of time or RPE over the first three rounds.

After Round 3 there were too few participants and no further statistical analysis could be done. Cronbach's Alpha was used to explore the internal consistency of the DALDA questionnaire.

### 3.2.6 Ethical Considerations

Ethics approval for this study was sought through the Human Research Ethics Committee (HREC) of the Faculty of Health Sciences, University of Cape Town, prior to commencement of study. This study adhered to the ethical standards outlined in the Declaration of Helsinki (Fortaleza, Brazil, 2013). Ethics approval was granted by the University of Cape Town, Faculty of Health Sciences Human Research Ethics Committee (HREC REF: 244/2014)

Once ethics approval had been granted, the recruitment process commenced according to the criteria stipulated for this study. All participants were required to complete a consent form in order to take part in the study. All participants' data were kept confidential by allocating a specific alphanumerical code to the participant. Additionally the data set was only available to researchers using an access password. All participants were given the opportunity to withdraw at any time during the study.

All participants were advised that this is a data collection study and their participation would add value to the pool of knowledge currently available. Information from this study has been made available to all squash regulatory bodies for developing the sport.

Due to the study utilizing self-assessment surveys using the Magpi application there were no physical risks associated with this study. Due to the fact that the DALDA assessment specifically did not diagnose any emotional or mental illness, but was a tool for highlighting stressful components in participants' daily life it was found that the emotional or psychological risks was negligible. Participants in the study completed the informed consent as well as the surveys related to medical history, DALDA, Injury incidence and RPE. Due to the nature of the sport there were physical risks not specifically related to the study.



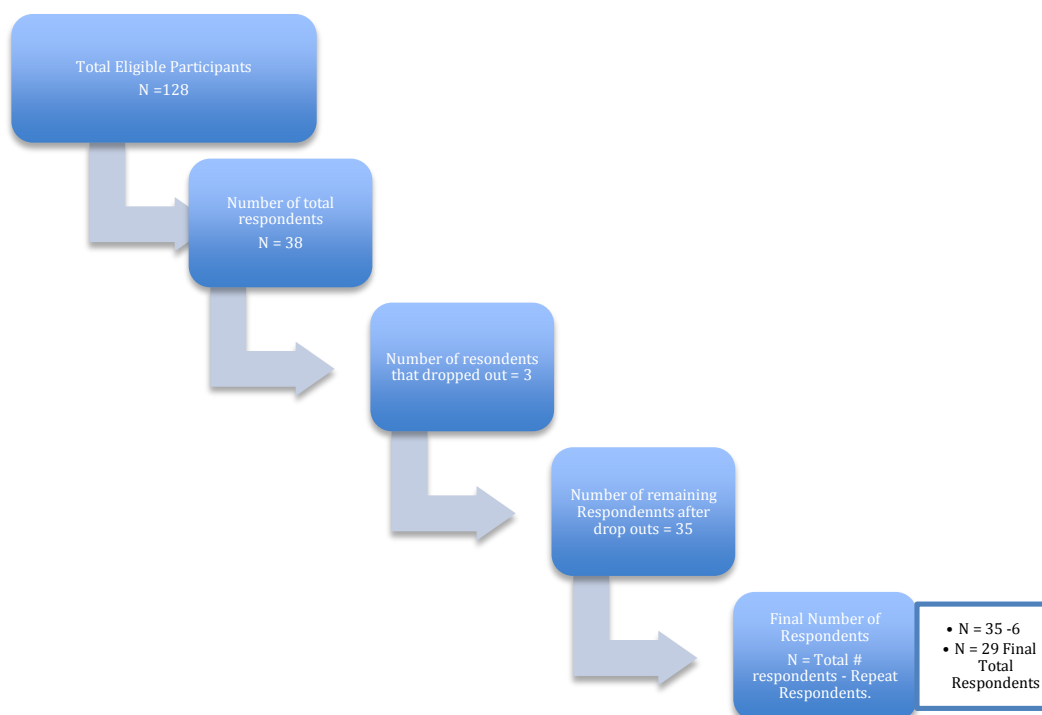
Any participant who was injured was immediately referred to relevant medical practitioner of the tournament for assessment and treatment. This facility was however, never required in any of the tournaments that were being used for data collection.

The benefits to the participants who were semi-professional and professional players included a possible gain in understanding of their daily stress and mental state and their levels of exertion while participating in squash tournaments. The results of the study will also be fed back to the South African squash playing community via email and the Squash SA and Western Province Squash administration. This will hopefully raise awareness of the importance of adequate stress management.

## 4 Chapter 4: Results

### 4.1 Participants and Recruitment

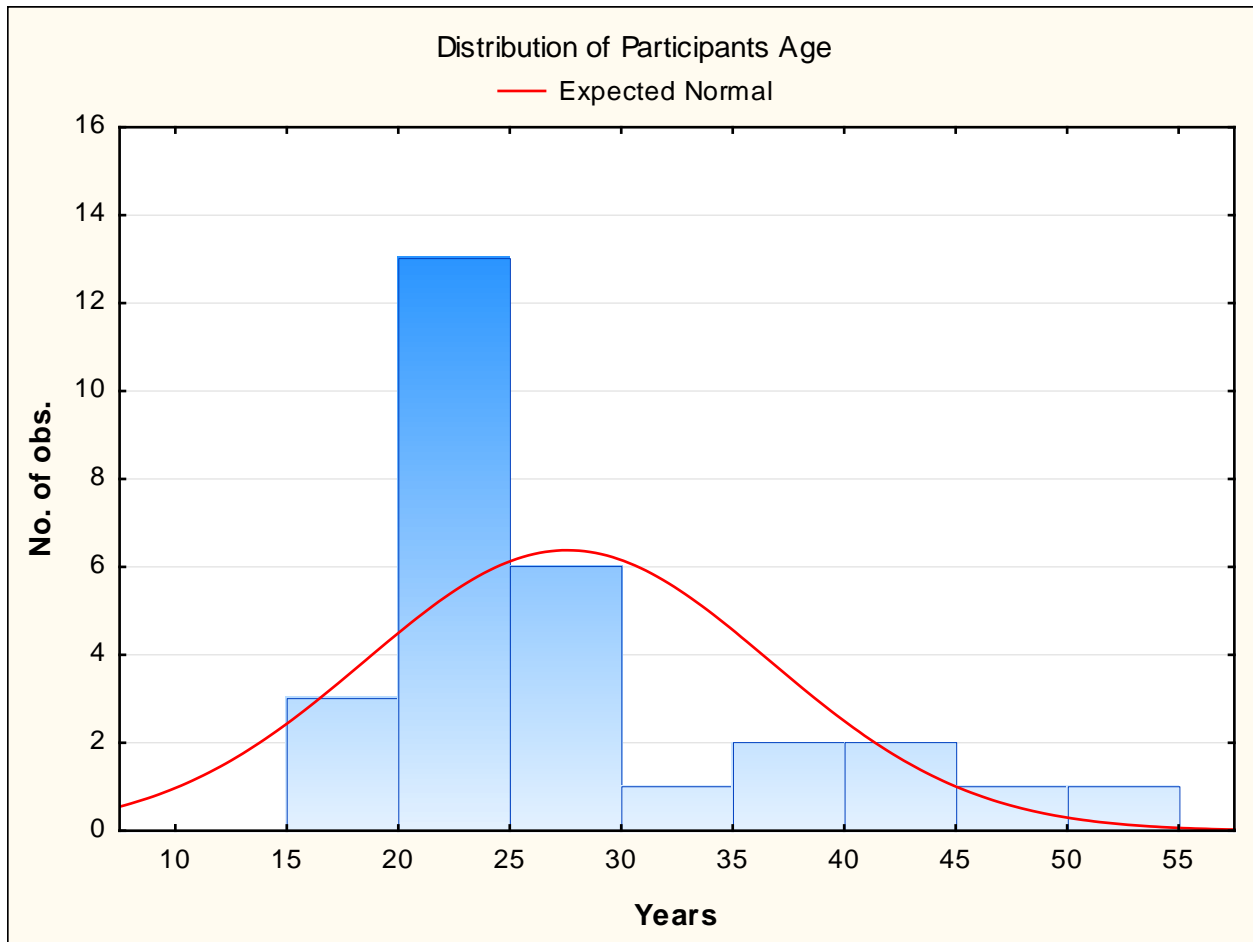
There were 128 potential participants across all four tournaments but due to several players participating in more than one tournament this lowered our overall number of participants. In all the tournaments, there were only two participants that withdrew from the study. Those participants that withdrew from this study did so due to not wanting to participate further as they felt it distracted them from preparing for their match. This took place very early in the study after the first round, which they had won. The total number of respondents across all the tournaments that had given consent to participate in the study was 38. Six respondents filled in the questionnaire at more than one tournament and their demographic data was only entered once. Likewise, those respondents that participated in more than one tournament had only the one set of data, which represented their furthest progression through a tournament used for data analysis. The final number of participants was 29.



**FIGURE 4-1: SUMMARY OF STUDY SAMPLE**

## 4.2 Demographic and Anthropometric Data

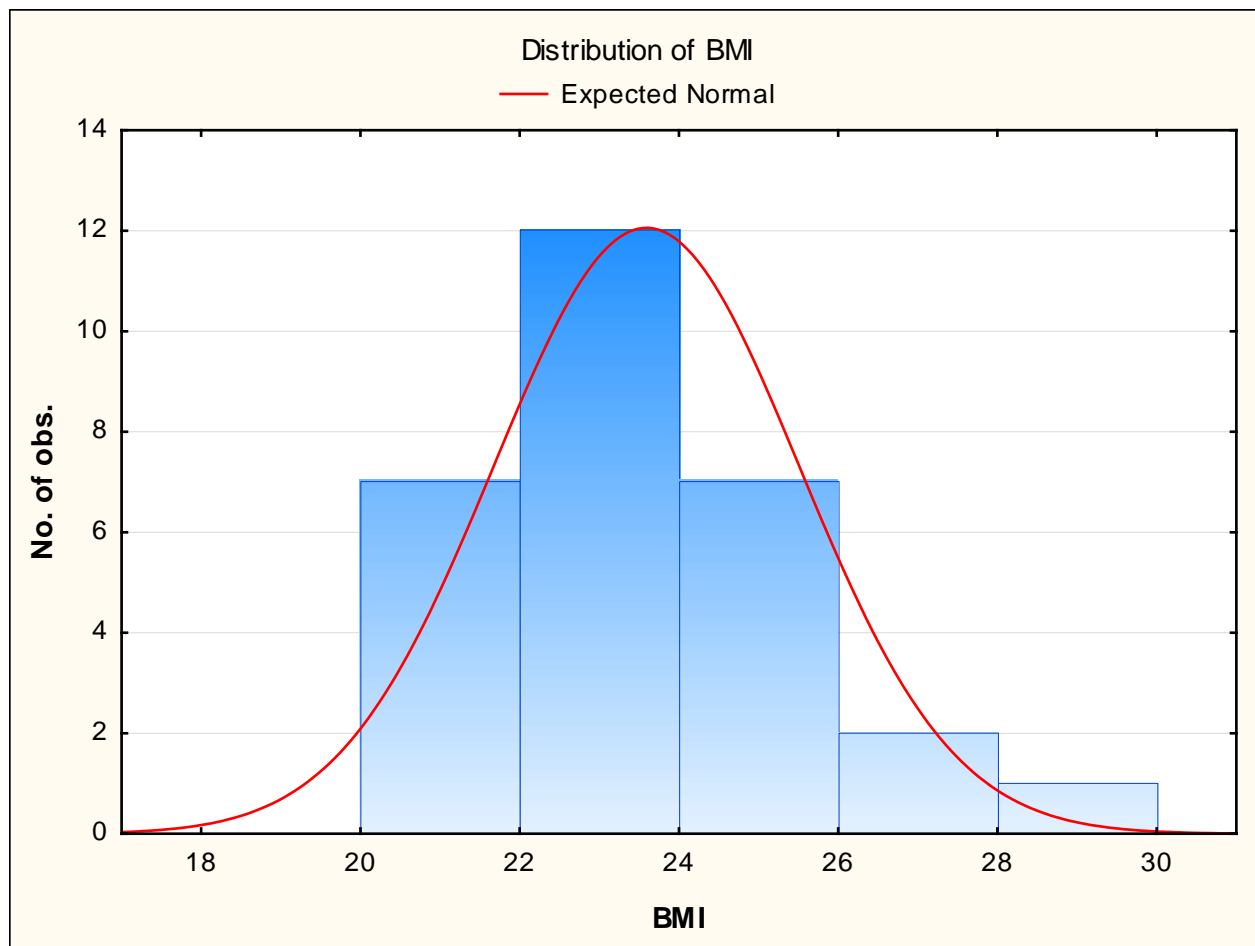
The mean age of participants was 27.6 (SD = 9.07). The data were not normally distributed (Kolmogorov-Smirnov, K-S d = .259,  $p < .05$ ) as seen in Figure 4-2 with a peak at 20-25 years and a range from 15 to 55 years.



N=29

**FIGURE 4-2: DISTRIBUTION OF PARTICIPANTS AGE**

The mean BMI was 23.6 (SD = 1.92). According to the WHO there are specific categories related to BMI which are as follows: Underweight (BMI < 18kg/m<sup>2</sup>), overweight BMI ≥ 25 kg/m<sup>2</sup>) and obese (BMI ≥ 30 kg/m<sup>2</sup>) (128). Six participants had a BMI ≥ 25 and were thus, the highest value being 29.14 kg/m<sup>2</sup>.



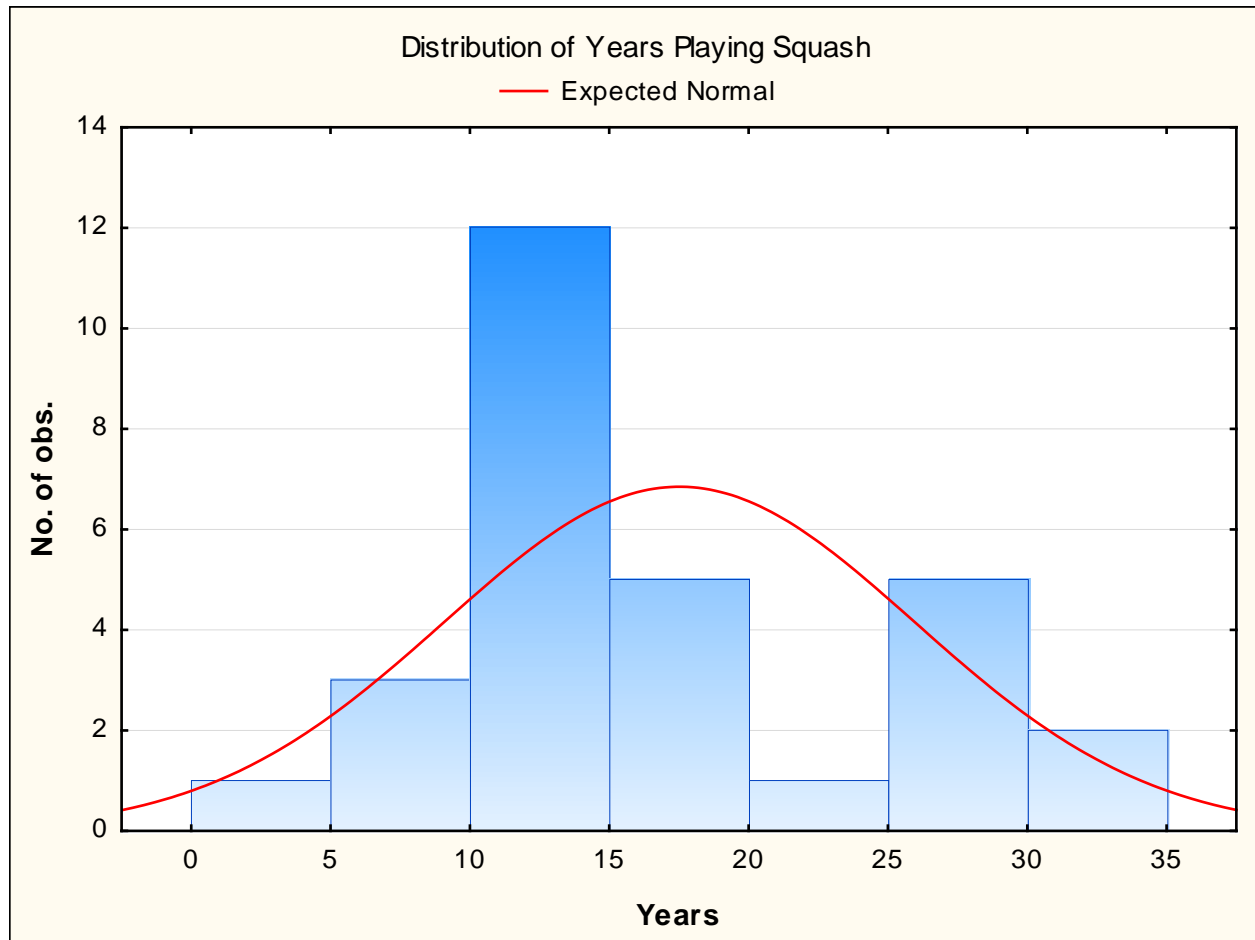
N=29

**FIGURE 4-3: DISTRIBUTION OF PARTICIPANTS BMI**

All but one of the participants reported having had a previous injury that prevented them from participating in squash activities for a period. However, only one participant reported an injury during all tournaments. The injury that was reported was that of a calf muscle. This was due to the participant not being adequately conditioned and also due to a previous calf injury.

### 4.3 Years Playing Squash

The mean number of years playing squash was 17.5 (SD = 8.45) As shown in Figure 4-4, the range was from 5 years to 35 years, with 12 respondents playing for between 10 and 15 years.



N=29

**FIGURE 4-4: DISTRIBUTION OF PARTICIPANTS YEARS PLAYING SQUASH**

In summary, 13 of the respondents (45%) were 20-25 years of age, had a BMI of 22-24 and had played squash for 10-12 years.

#### 4.4 Match-related Information

As this was a longitudinal study, repeated measures of the dependent variables were taken. However, as it was a knockout tournament, the number of people eligible to respond decreased per round as others were eliminated by their opponents. There were therefore 29 first round responses, 17 second round responses and 10 third round responses from the two tournaments combined. Fourth and fifth rounds were not looked at, as the numbers were too low to be statistically valid. As the exact time of each match was not known, categories for match times were entered as follows:

1 = 20-29min

2 = 30-39min

3 = 40-49min

4 = 50-59min

5 = 60-69min

6 = 70-80min

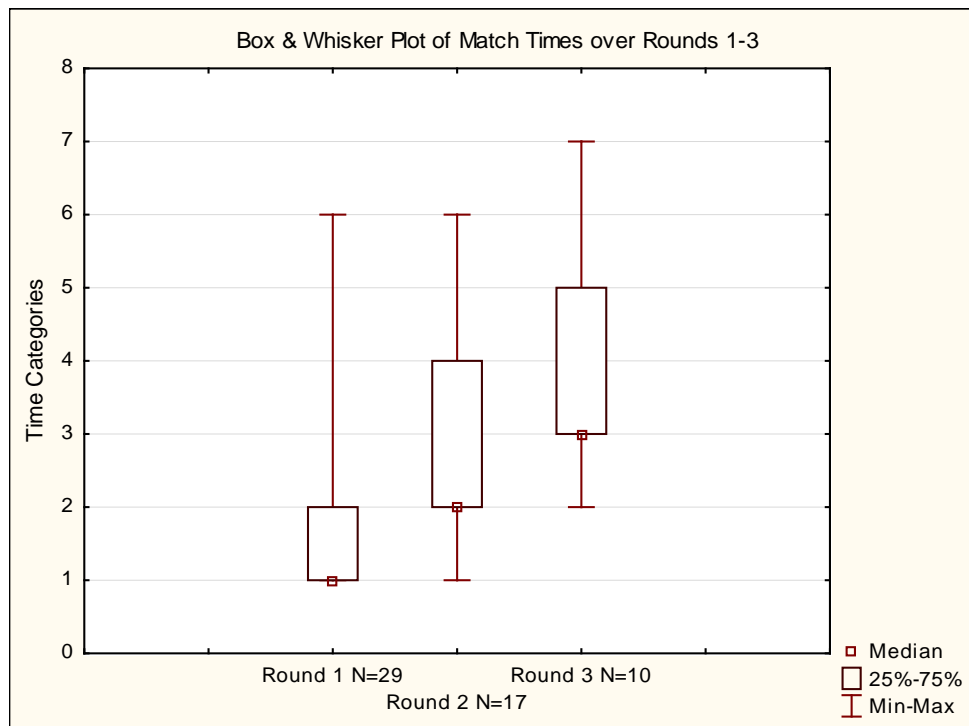
As can be seen in Table 4-1, the average ranking of the time taken for each match for each round increased significantly from the first to the third round (ANOVA Chi-sq. =17.2,  $p < .001$ )

**TABLE 4-1: FRIEDMAN ANOVA OF MATCH TIMES OF ROUNDS 1 – 3**

ANOVA Chi Sir. (N = 10, df = 2) = 17.2 p <.001		
	Average Rank	Sum of Ranks
<b>Match Times Round 1</b>	1.05	10.5
<b>Match Times Round 2</b>	2.10	21.0
<b>Match Times Round 3</b>	2.85	28.5

Figure 4-5 depicts the results from the Friedman ANOVA by describing the medians and quartiles of the time taken for each round.

The ANOVA Chi square of match times was  $p < .001$  which implies that match times increased are statistically significant and different as one progresses through rounds one to three. The median time increased from 20-30 minutes, to 30-40 minutes in Round 2 and 40-50 minutes in Round 3. In general rounds 1 to 3 had the greatest number of players for meaningful statistics to be generated.



**FIGURE 4-5: BOX-WHISKER PLOT OF MATCH TIMES OVER ROUNDS 1 - 3**

#### 4.5 DALDA Results

As the DALDA utilizes a categorical scale, frequency tables were used to describe the data. The DALDA has an A and a B section, which represents the Sources of stress and the Symptoms of stress respectively. The internal consistency of Part A, (Sources of stress scale), was 0.531 and the removal of no item raised the alpha value above 0.6. The internal consistency of Part B, (Symptoms of Stress), was 0.823 and the removal of no item reduced alpha to less than 0.830.

#### 4.5.1 Sources of Stress

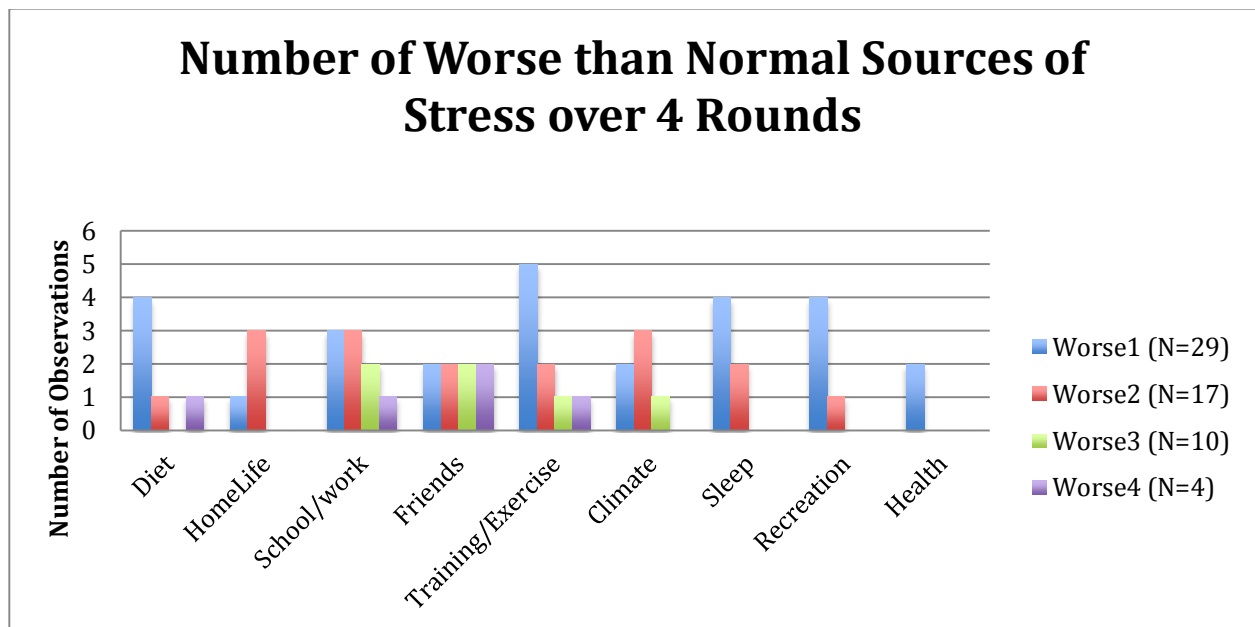
In Round 1, 51.7% the respondents reported having no sources of stress. This dropped to 35.3% in Round 2 and then rose to above 66.7% for the last two rounds. The greatest proportion of respondents reported stress sources in Round 2 but due to the small numbers, no tests were done (Table 4-2: Frequency Table of Number of Sources of Stress over 4 ). Round 5 was excluded due to there only being 2 participants.

**TABLE 4-2: FREQUENCY TABLE OF NUMBER OF SOURCES OF STRESS OVER 4 ROUNDS**

<b>Number of Sources of stress</b>	<b>Round 1</b>	<b>Round 2</b>	<b>Round 3</b>	<b>Round 4</b>
<b>0</b>	15 (51.7%)	6 (35.3%)	7 (70%)	2 (66.7%)
<b>1</b>	6 (20.7%)	6 (35.3%)	1 (10%)	0 (0%)
<b>2</b>	4 (13.8%)	4 (23.5%)	1 (10%)	1 (33.3%)
<b>3</b>	3 (10.3%)	1 (5.9%)	1 (10%)	0 (0%)
<b>4</b>	1 (3.4%)	0 (0%)	0 (0%)	0 (0%)
<b>Total</b>	29	17	10	4
<b>Missing (Eliminated from the tournament)</b>	0	12	19	25



As can be seen in Figure 4-6 the main sources of stress included diet, training, sleep and recreation in Round 1, home life, school/work and climate in Round 2 and school/work and friends in Round 3. It is difficult to ascertain whether there is a greater number of worse than normal over the four rounds as there is a steady drop in participants through the rounds.



**FIGURE 4-6: DALDA SOURCES OF STRESS OVER 4 ROUNDS**

Table 4-3 below shows the part A sources of stress that were tested by the DALDA. In the table below the highlighted cells represent the items of the DALDA part A that had the greatest number of worse than normal amongst the participants in each round. For every item, more respondents felt better than worse, apart from Social/work, Training/exercise and Sleep in Round 1. In Round 2 and 3, more participants reported having more problems in Social/work, Climate and Sleep. In Round 3, only Climate was worse and in Round 4, more respondents had reported worse Social/work, Friends, Climate and Sleep, although the numbers were very small. In each round, by far the greatest number reported the source of stress to be normal.

**TABLE 4-3: FREQUENCY TABLE OF NUMBER OF STRESSORS IN DALDA PART A OVER 4 ROUNDS**

	Round 1			Round 2			Round 3			Round 4		
DALDA Part A	Worse	Normal	Better	Worse	Normal	Better	Worse	Normal	Better	Worse	Normal	Better
Diet	4	17	10	2	18	6	0	6	7	1	5	3
Home life	1	16	12	4	14	8	0	6	8	0	6	3
Social/work	5	24	2	6	17	3	3	8	4	1	8	0
Friends	2	15	14	3	15	8	2	6	3	2	6	1
Training/exercise	6	13	12	4	12	10	1	6	6	1	6	2
Climate	3	23	5	4	19	2	3	8	2	1	8	0
Sleep	5	17	9	6	18	2	2	7	3	2	7	0
Recreation	4	22	5	4	18	4	0	8	1	0	8	1
Health	3	17	11	4	15	7	1	6	5	0	6	3

## Symptoms of Stress

Table 4-4 describes the frequency of symptoms of stress of the participants. The table below shows highlighted cells that represent the greatest number of worse than normal items of the DALDA part B that the participants had in each round. It is evident that the bulk of the stresses were found in round 2 of tournaments and also in round 3. The types of stresses that were present varied across the rounds but muscle pains and tiredness was the most represented across all rounds.

**TABLE 4-4: FREQUENCY TABLE OF NUMBER OF STRESSORS IN DALDA PART B OVER 4 ROUNDS**

	Round 1			Round 2			Round 3				Round 4		
DALDA Part B	Worse	Normal	Better	Worse	Normal	Better	Worse	Normal	Better		Worse	Normal	Better
Muscle Pains	5	22	4	8	14	4	9	9	3		4	4	1
Techniques	2	19	10	1	22	3	1	13	3		1	7	1
Tiredness	2	24	5	6	18	2	3	12	2		1	8	0
Need rest	2	23	6	4	19	3	1	15	1		0	9	0
Supplement work	3	16	11	3	17	6	3	12	2		2	5	3
Boredom	2	14	15	2	18	6	1	12	4		0	7	3
Recover	3	21	7	0	22	4	2	11	4		0	8	1
Irritability	1	22	8	6	18	2	1	15	1		1	7	1
Weight	2	26	3	4	20	2	1	15	1		1	7	1
Sore throat	4	18	9	6	13	7	1	10	6		1	6	2
Internal	2	16	13	9	19	2	0	15	2		1	7	1
Unexplained aches	4	17	10	7	15	4	3	9	5		1	5	3
Techniques/Power	1	22	8	1	21	4	0	14	3		1	8	0
Enough Sleep	2	22	7	6	16	4	2	13	2		2	7	0
Between session recovery	4	22	5	3	20	3	2	10	1		1	8	0
General weakness	2	17	12	4	15	7	2	8	5		3	4	2
Interest	0	8	23	1	14	11	1	13	8		0	7	2
Arguments	5	17	9	4	16	6	1	9	3		2	6	1
Skin rashes	2	21	8	1	14	11	0	11	8		0	6	3
Congestion	3	22	6	6	13	7	1	7	5		0	7	2
Training effort	4	6	4	4	12	10	1	14	9		0	5	4
Temper	7	15	2	2	18	6	1	10	2		0	7	2
Swelling	1	18	12	0	14	12	0	11	7		0	6	3
Likeability	1	23	7	1	20	5	1	11	5		0	8	1
Running Nose	4	20	7	5	17	4	0	11	6		0	6	3

Figure 4-7 shows the number of worse than normal observations of the participants over the four rounds. The highest number of “Worse than normal” responses were temper, followed by muscle pains, irritability, unexplained aches, arguments and training effort in Round 1; muscle pains and irritability in Round 2; muscle pains and tiredness in Round 3; and general weakness in Round 4. However, particularly in Round 1, more respondents reported better rather than worse symptoms in the other items.

## Number of Worse than normal Symptoms of Stress over 4 Rounds

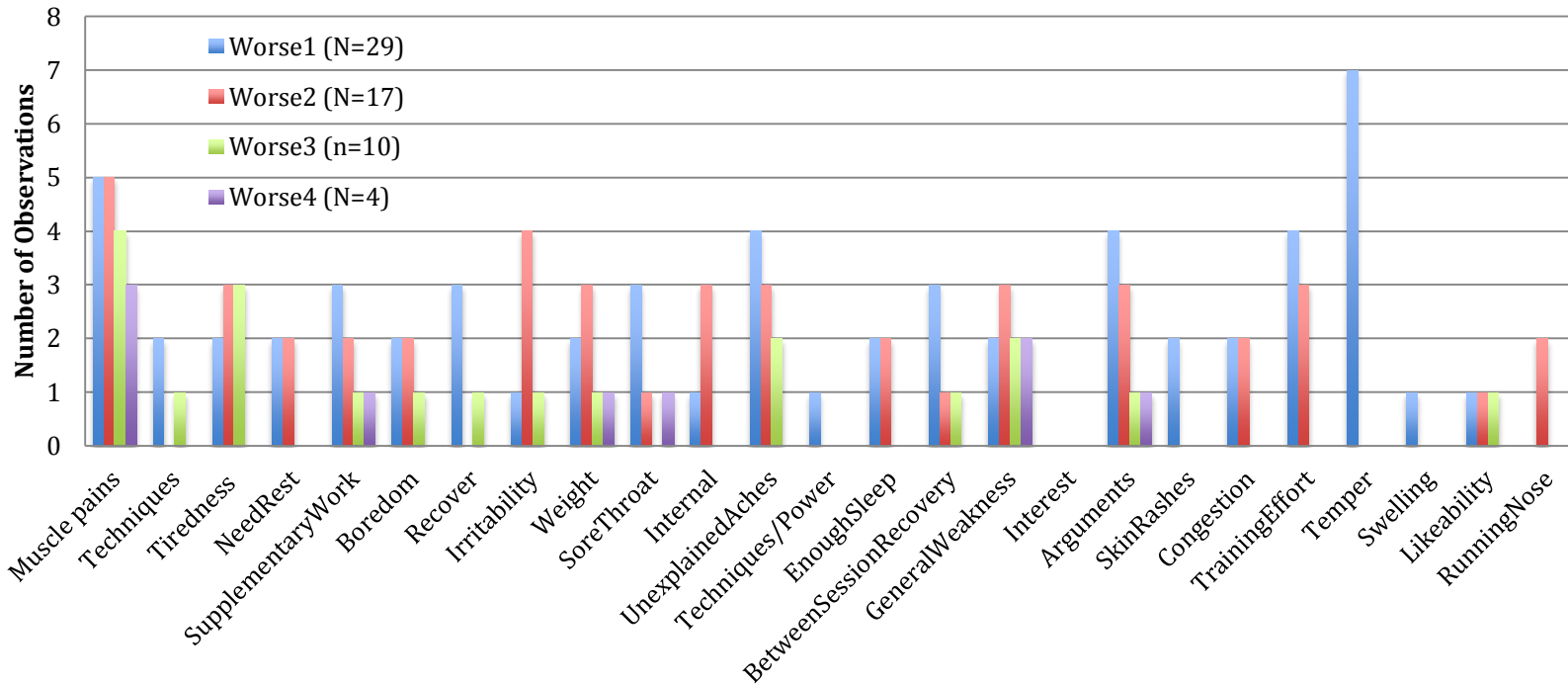


FIGURE 4-7: DALDA SYMPTOMS OF STRESS OVER 4 ROUNDS

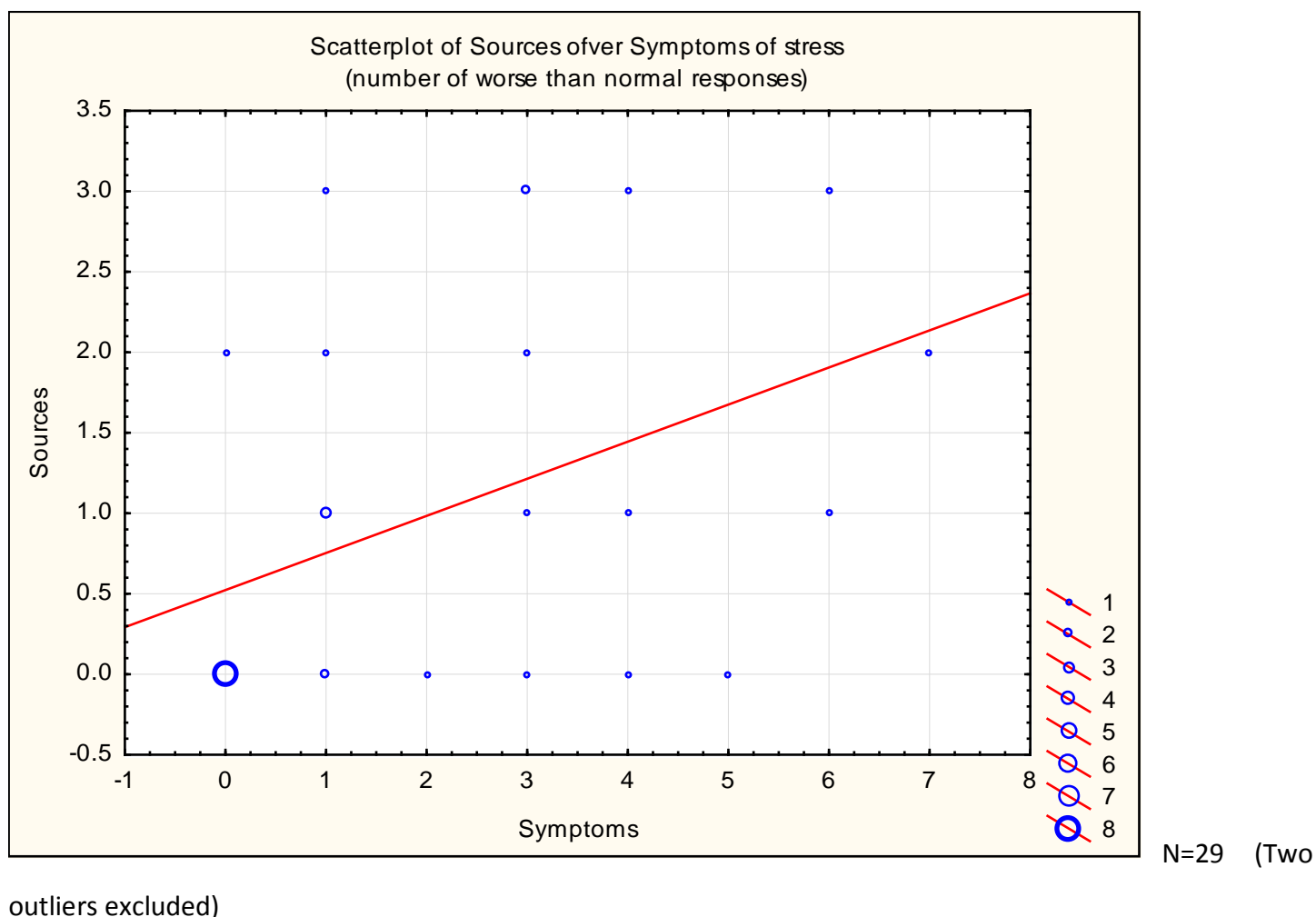
Table 4-5 shows the symptoms of stress over four rounds. In Round 1, 35% of participants had no symptom of stress; in Round 2, 33% of participants had no symptoms of stress; and in Rounds 3 and 4, 20% and 25% of participants had no symptoms of stress respectively. There were thus greater proportions reporting stress in the last two rounds but due to the small numbers, no tests were done.

**TABLE 4-5: FREQUENCY TABLE OF NUMBER OF SYMPTOMS OF STRESS OVER 4 ROUNDS**

<b>Number of Symptoms of Stress</b>	<b>Round 1</b>	<b>Round 2</b>	<b>Round 3</b>	<b>Round 4</b>
<b>0</b>	10	6	2	1
<b>1</b>	7	2	4	0
<b>2</b>	1	3	2	2
<b>3</b>	4	1	0	0
<b>4</b>	2	2	0	0
<b>5</b>	1	0	0	1
<b>6</b>	2	2	2	0
<b>7</b>	1	2	0	0
<b>9</b>	1	0	0	0
<b>Total</b>	29	18	10	4
<b>Missing (Eliminated from the tournament)</b>	0	11	19	25

A scatterplot of the sources and symptoms of stress indicated that there were two outliers who scored high on the one and low on the other. Once these two were excluded, a positive significant correlation was found between the number of sources and number of symptoms of stress ( $r=0.419$ ,  $p=0.024$ ) as seen in Figure 4-8.





**FIGURE 4-8: SCATTERPLOT OF SOURCES OF STRESS VS. SYMPTOMS OF STRESS IN ROUND 1**

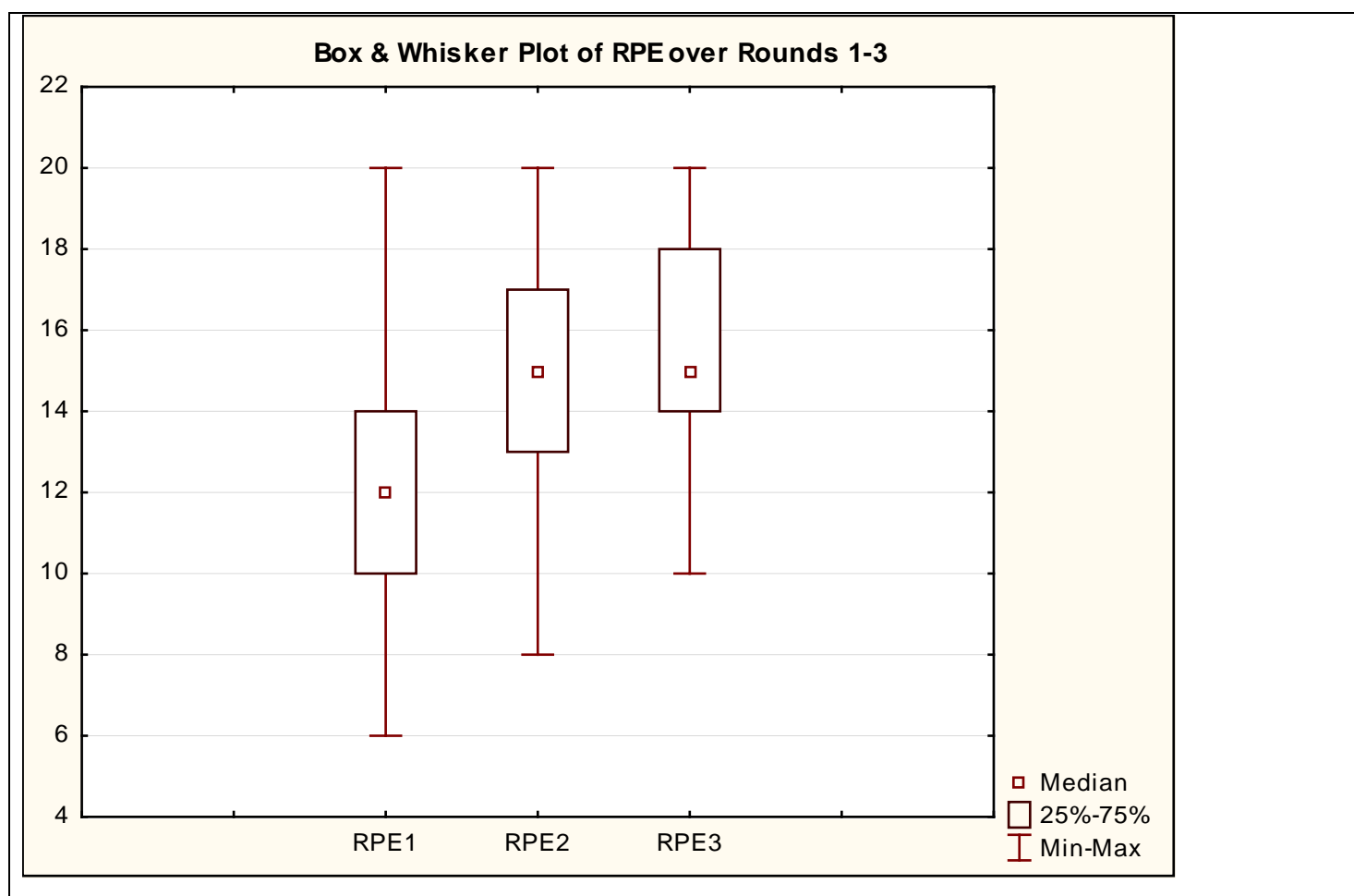
#### 4.6 RPE results

As the sample size was small (only ten in the final sample) and the data were not normally distributed, the RPE scores were treated as ordinal data. In Round 2, the median value of the 17 respondents was 14.9 and in Round 3, it was 15.3 as reported by the 10 participants. Table 4-6 summarizes the data for the participants RPE in rounds 1, 2 and 3 respectively. Round 4 was excluded due to there only being 2 participants. There was a significant difference among the distributions of the RPE of participants over the three rounds ( $p=.001$ ) based on the Friedman's ANOVA test.

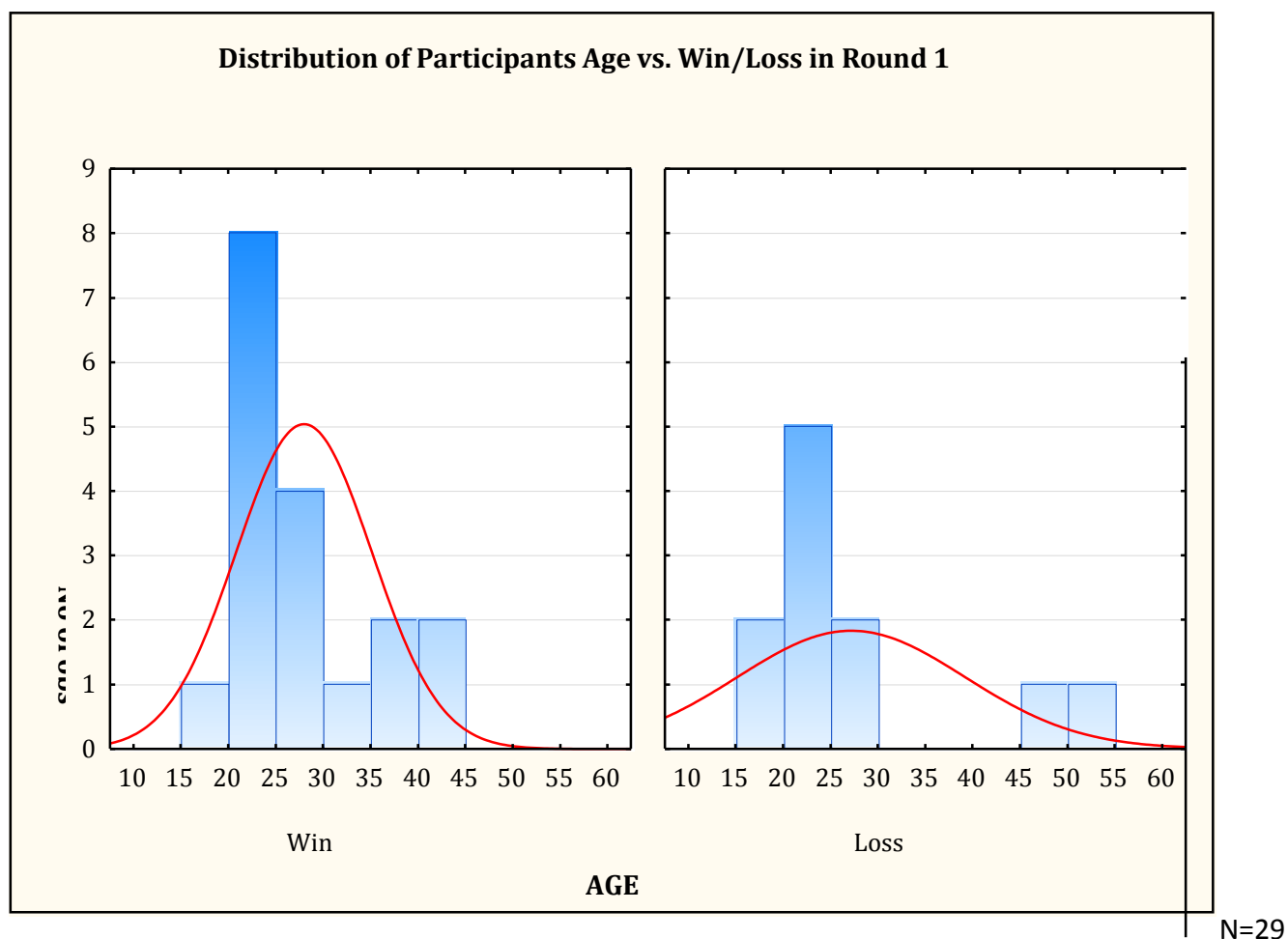
**TABLE 4-6: FRIEDMAN ANOVA TABLE OF RPE IN ROUNDS 1,2 AND 3**

	ANOVA Chi Sqr. (N = 10, df = 2) = 13.5 p = .001				
	<b>Average Rank</b>	<b>Sum of Ranks</b>	<b>Median</b>	<b>Range</b>	<b>Std.Dev.</b>
<b>RPE1</b>	1.2	12	12	14	2.2
<b>RPE2</b>	2.0	20	15	12	2.8
<b>RPE3</b>	2.8	28	15	10	2.9

It can be seen in Figure 4-9 that the difference lay between the lower median RPE of the Round 1 and the following two rounds. The RPE increased significantly from Round 1 to Round 2.

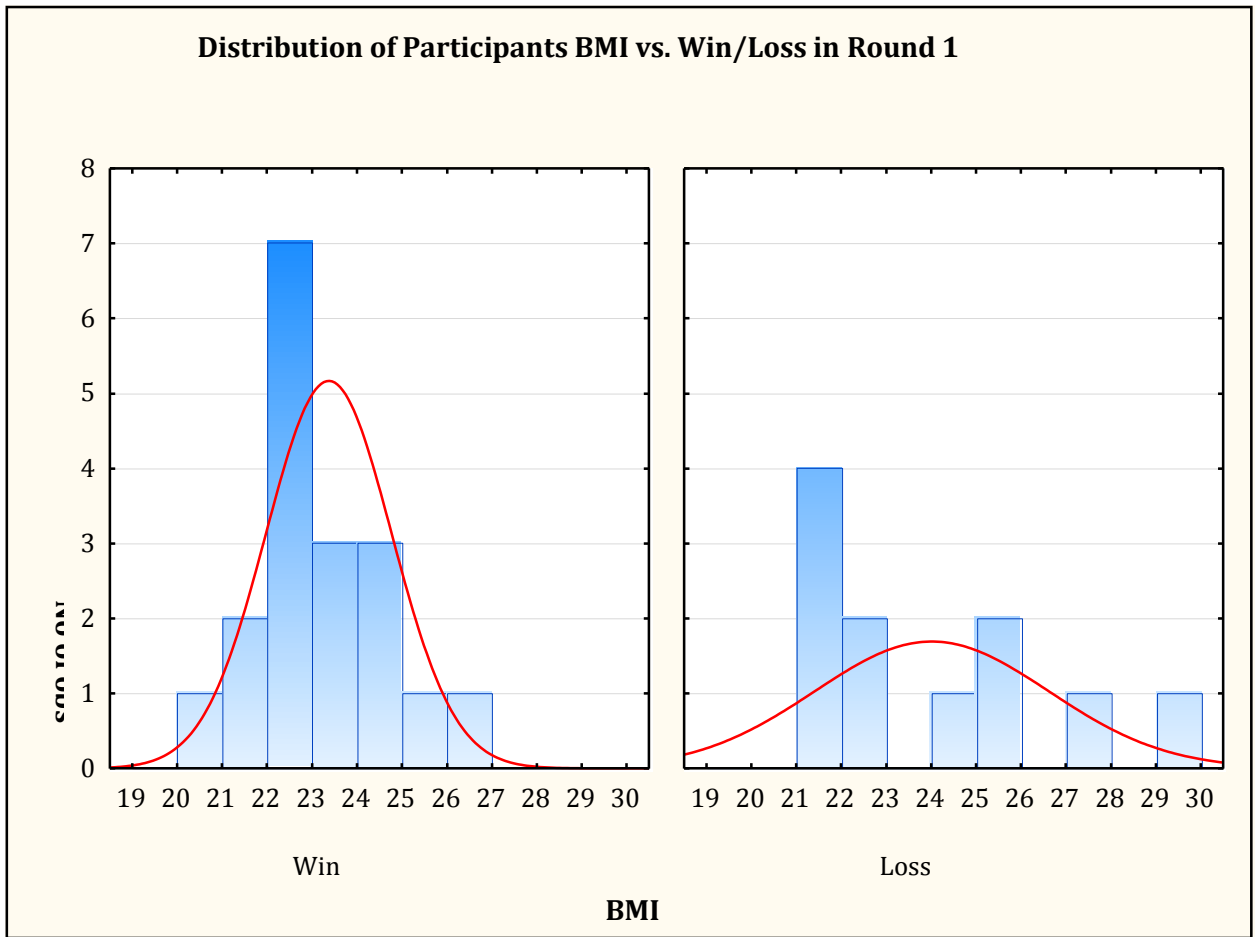


**FIGURE 4-9: BOX-WHISKER PLOT OF PARTICIPANTS RPE IN ROUNDS 1,2 AND 3**



**FIGURE 4-10: DISTRIBUTION OF PARTICIPANTS AGE VS. WIN/LOSS IN ROUND 1**

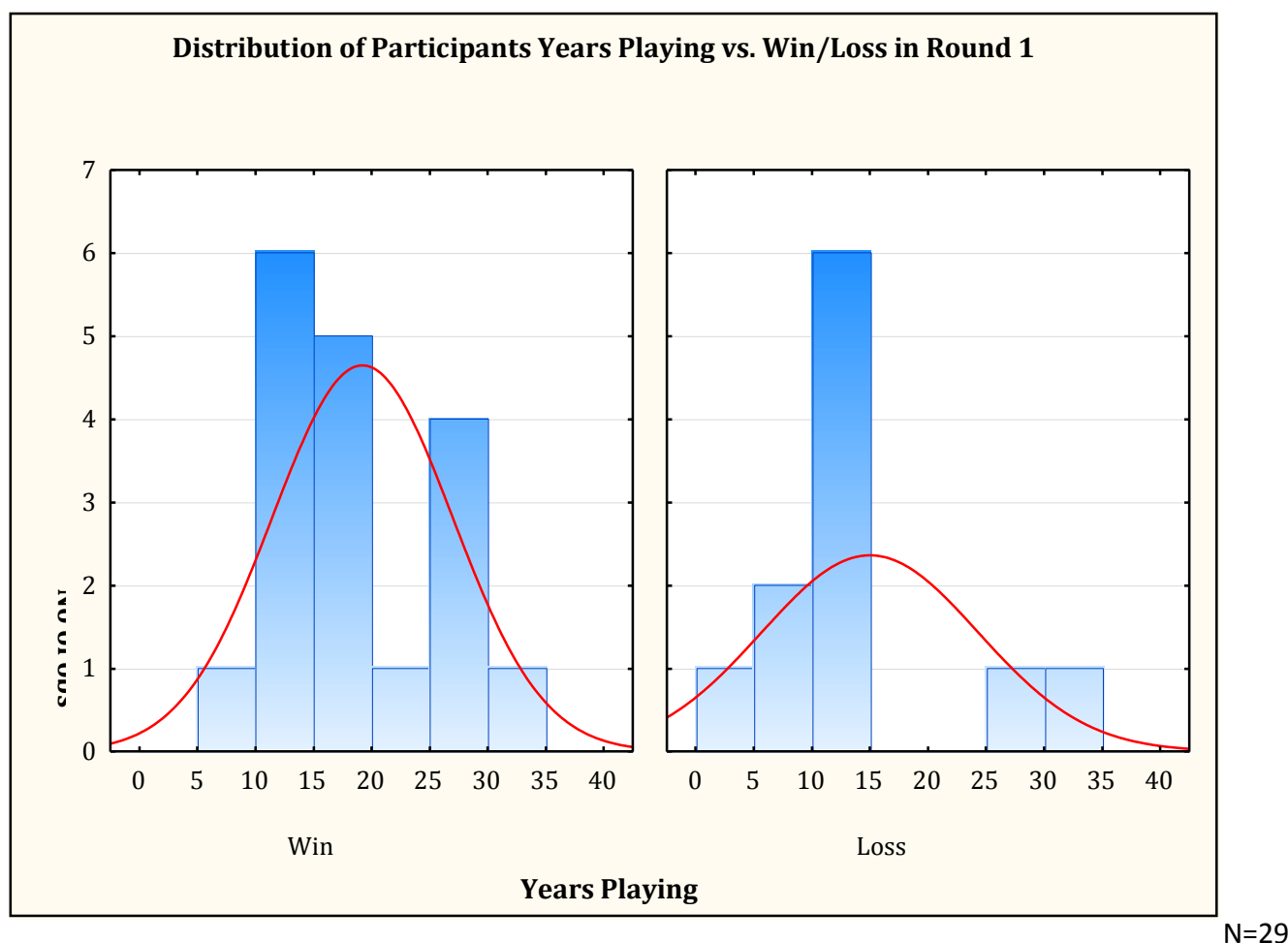
Figure 4-10 shows the distribution of Age vs. Win/Loss in Round 1 of competitions. The distribution of age of participants who lost in the first round was not evenly spread across the age groups. The bulk of the participants who lost were 20-30 years old and 45-55 years old. The ages of winning participants are more evenly distributed from 15-45 years, with the bulk of the winners being between 20 and 25 years of age.



N=29

**FIGURE 4-11: DISTRIBUTION OF PARTICIPANTS BMI vs. WIN/LOSS IN ROUND 1**

Figure 4-11 shows the distribution of participants BMI vs. Win/Loss in Round 1 of the competition. The distribution of BMI of participants who lost shows a non-normal distribution. Participants who lost were grouped in the following: 21-22, 24-25, and two groups of 27 and 29 where 25-30 is considered to be in the overweight range (128). The distributions of winners for BMI were more evenly, but not normally distributed. Winners ranged from 20-26 with the bulk of the winners having a BMI of 22, which falls within the healthy BMI range of 20-25.



**FIGURE 4-12: DISTRIBUTION OF PARTICIPANTS YEARS PLAYING VS. WIN/LOSS IN ROUND 1**

Figure 4-12 shows the distribution of participants' number of Years Playing squash vs. Win/Loss in Round 1 of the competition. The bulk of the losers had been playing squash for less than 15 years. The greatest number of players winning had played squash for 10 years that would coincide with the participants who were 20-30 years of age. Table 4-7 indicates that participants winning or losing was statistically unrelated to Age, BMI or Years Playing squash.

**TABLE 4-7: MANN-WHITNEY U TEST FOR AGE, BMI AND YEARS**

	Rank Loss	Sum Loss	Rank Win	Sum Win	U	Z adjusted	p-value	Valid Loss	N	Valid Win	N
AGE		135.5		299.5	69.50	-1.31	0.190	11		18	
BMI		165.5		269.5	98.50	0.00	1.000	11		18	
YRS PLAYING		129.5		305.5	63.50	-1.58	0.114	11		18	

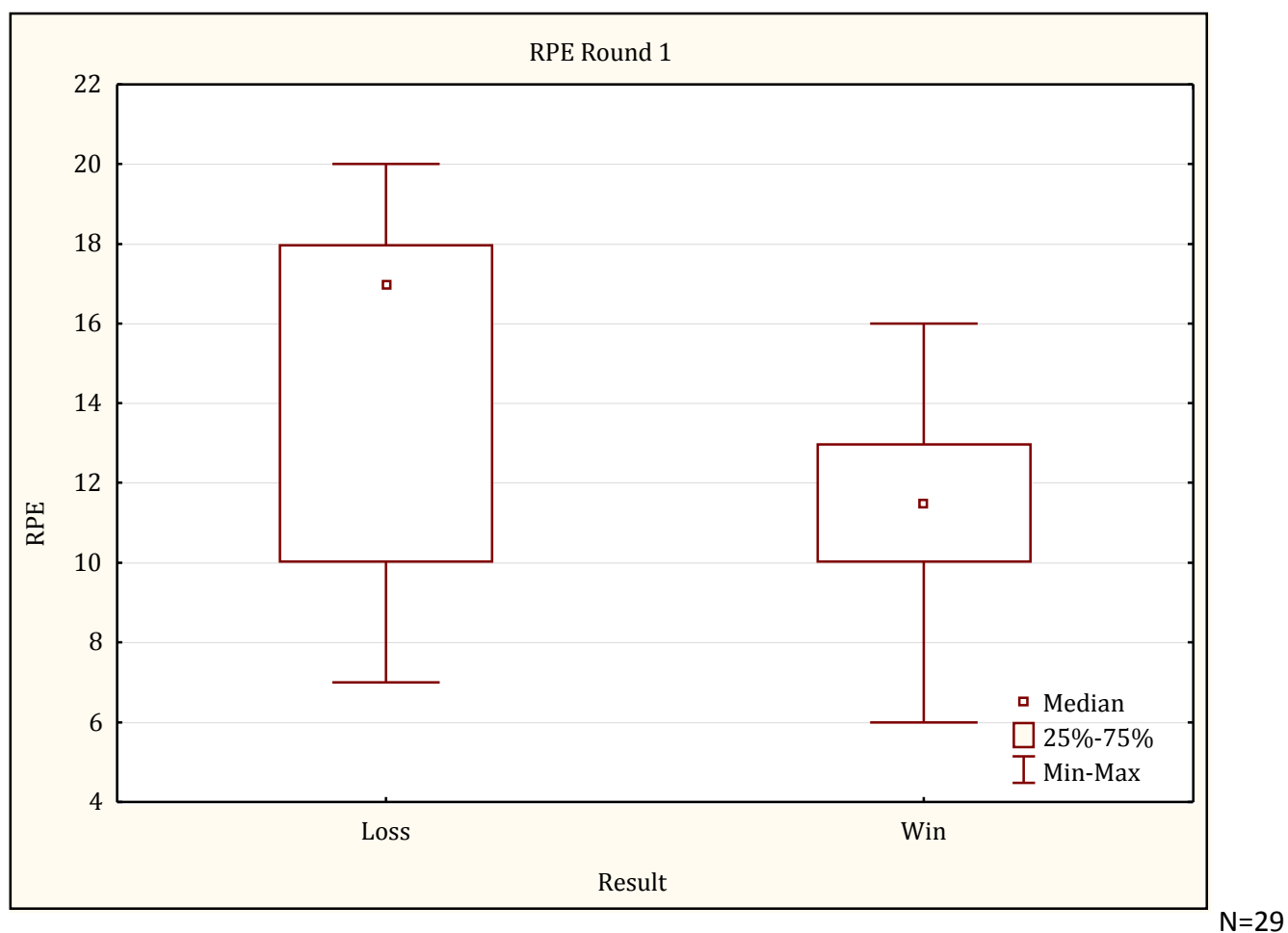
#### 4.8 RPE Comparisons

There was no correlation between years of playing squash and RPE ( $r=0.07$ ,  $p=.524$ ).

**TABLE 4-8: MANN-WHITNEY U TEST FOR RPE BY VARIABLE WIN/LOSS IN ROUNDS 1-3**

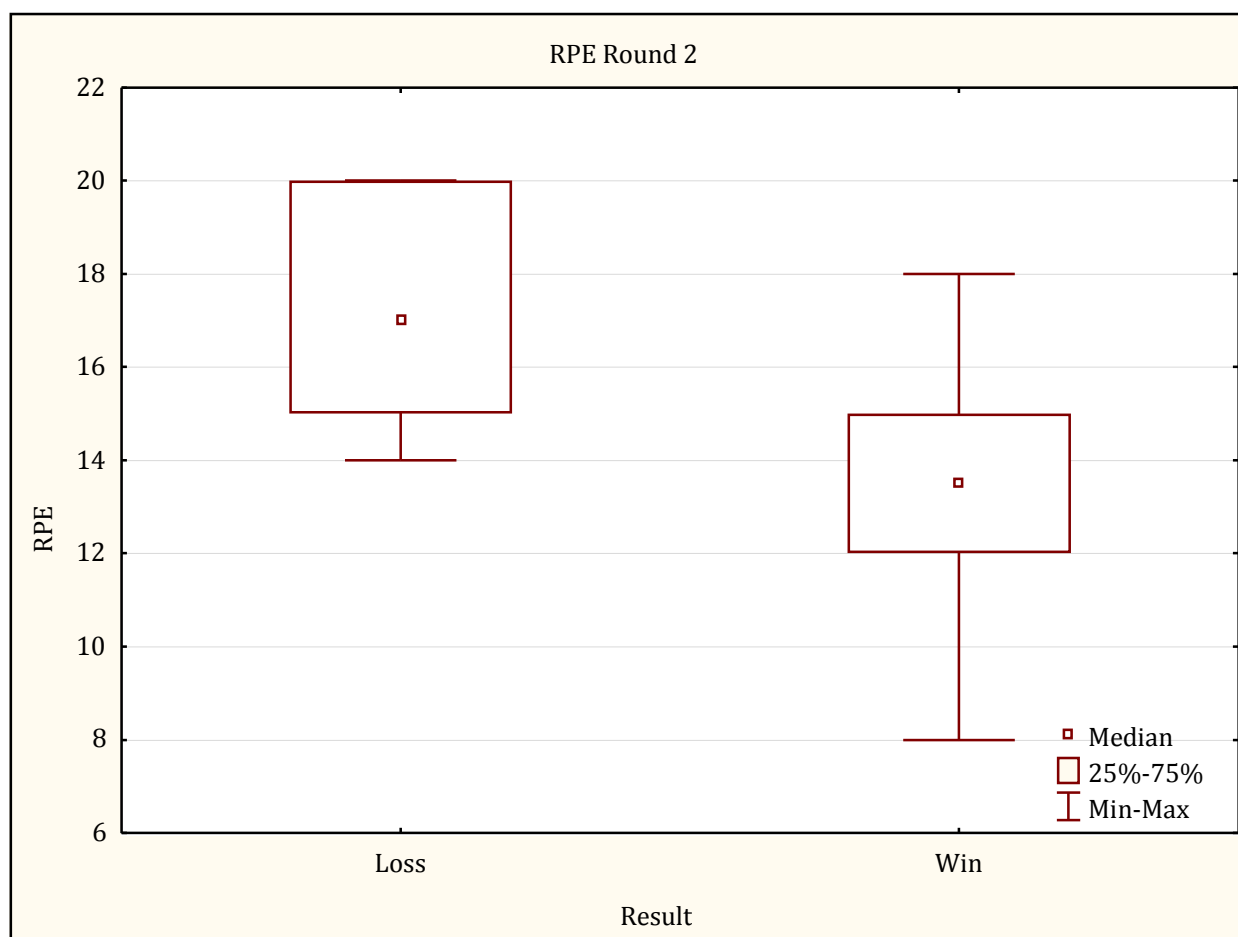
Round	Rank Sum – Loss	Rank Sum - Win	U	Median	Z - adjust ed	p-value	Valid N - Loss	Valid N - Win
1	205.5	229.5	58.50		1.810	0.070	11	18
2	88.500	64.500	9.500		2.4625	0.014	7.0	10.0
3	36.5	18.5	8.50		0.65	0.52	6	4
4							2	2
5								1

The Mann-Whitney U test indicated that there was a significant difference between RPE and Win/Loss in round 2 with a  $p=0.014$ . There were no significant differences in rounds 1 and 3 (Table 4-8) although in every case the winners reported less perceived exertion than the losers. There were too few participants in Round 4 and 5 to do statistical tests.



**FIGURE 4-13: CATEGORICAL BOX-WHISKER OF WIN/LOSS VS. RPE IN ROUND 1**

As can be seen in the above figure, the median score of the Losers in Round 1 was 17.0, compared to 11.4 in those who won. As the spread of scores was wide, particularly amongst those who lost, the difference was not statistically significant.

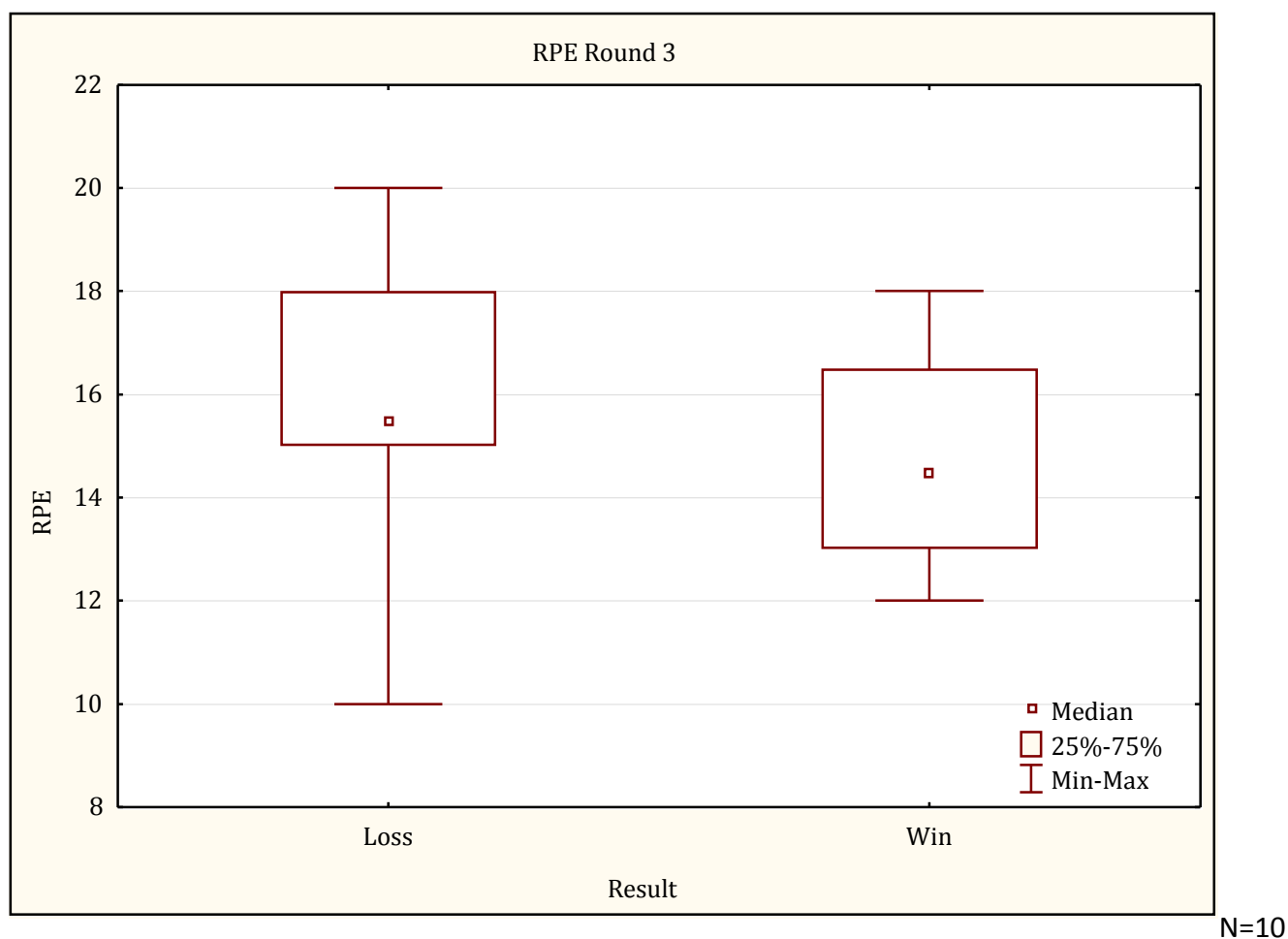


N=18

**FIGURE 4-14: CATEGORICAL BOX-WHISKER OF WIN/LOSS VS RPE IN ROUND 2**

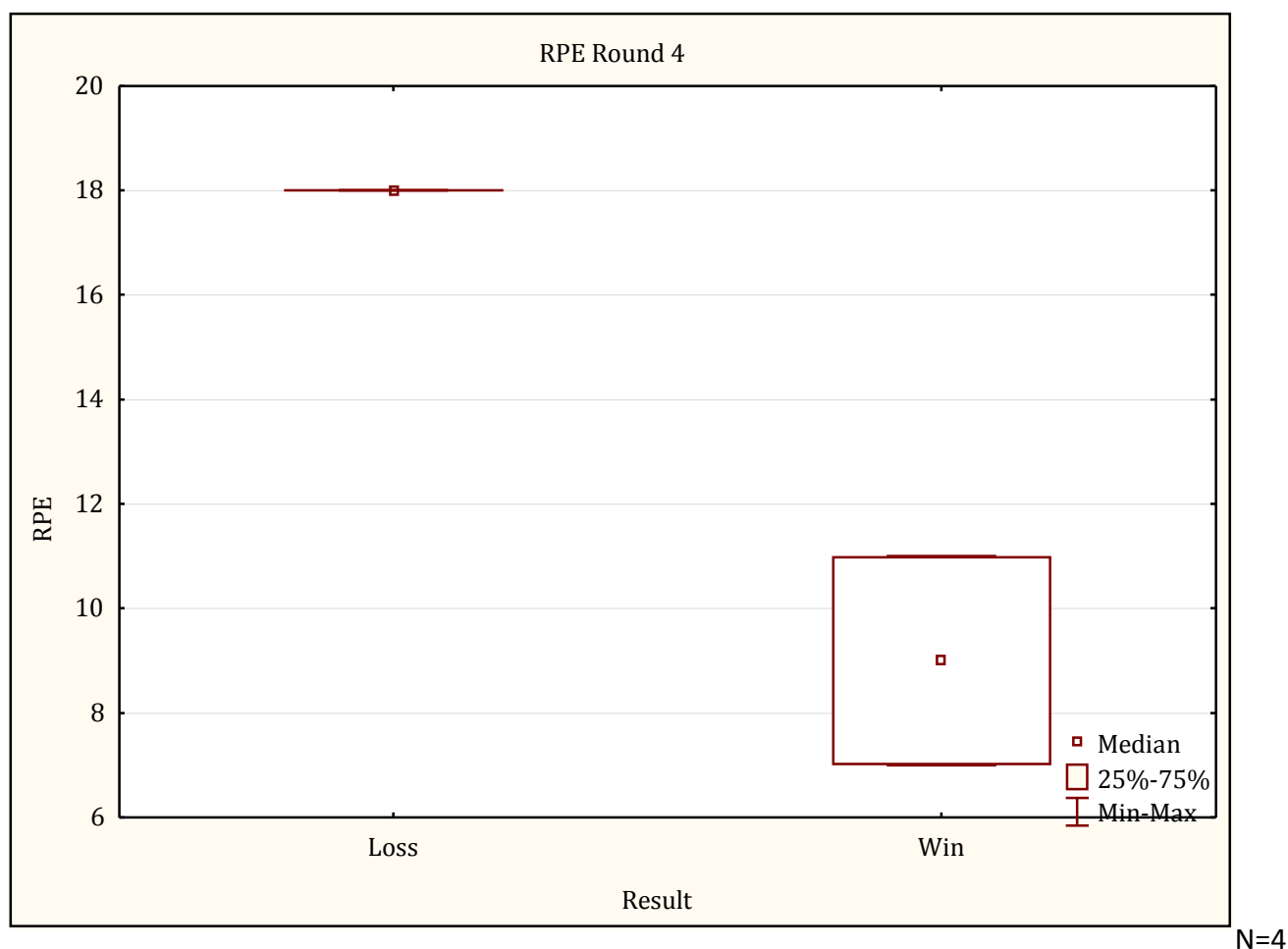
In Round 2 the median score was the same in those who had lost in Round 1 (17.0) but had increased to 13.5 (from 11.4) in the winners. There was a much wider range of scores in the winning group (Figure 4-14).





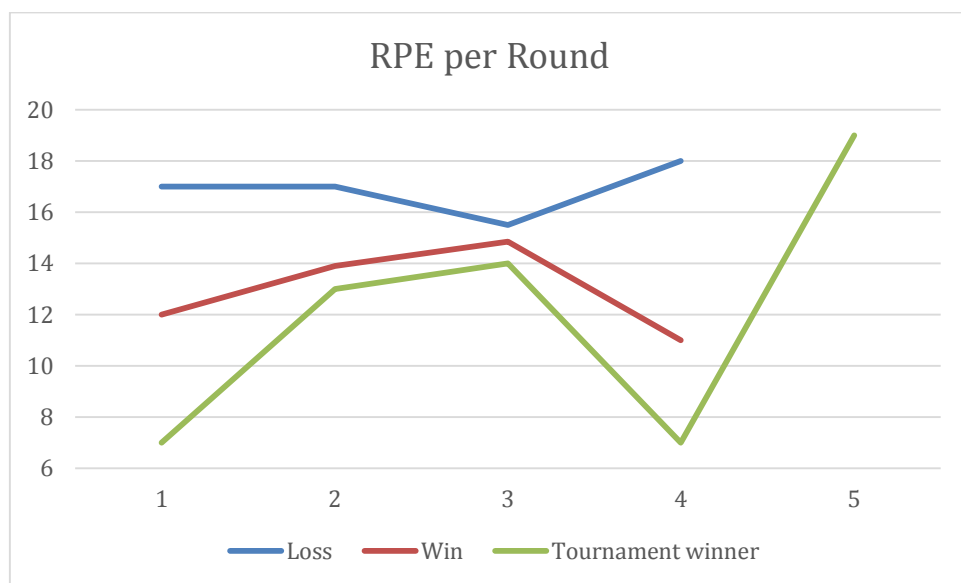
**FIGURE 4-15: CATEGORICAL BOX-WHISKER OF WIN/LOSS vs. RPE IN ROUND 3**

In Round 3, the median score of those who lost dropped to 15.5 and increased to 14.4 in the winning group. The spread of the scores of those who lost was very wide.



**FIGURE 4-16: CATEGORICAL BOX-WHISKER OF WIN/LOSS vs. RPE IN ROUND 4**

There were only two players who responded that went through to the final round, Round 5 and Figure 4-16: Categorical Box-Whisker of Win/Loss vs. RPE in round 4 indicates that the winner of the tournament reported a very similar, low RPE in the first four rounds. There was a large increase, however, in the final round. As these are single data points, no statistical test could be done.



**FIGURE 4-17: MEDIAN RPE ACROSS 5 ROUNDS**

Figure 4-17 presents the median RPE scores across rounds. It should be noted that the bulk of losers irrespective of round rated their RPE between 15 and 18, which is considered quite high on the Borg Scale. Winners on the other hand showed only high rated RPE mainly during the first 2 rounds. The winner in round 5 rated their RPE at 19 just short of maximum. Note that the number of participants decreased per round and that the Tournament winner was excluded from the “Win scores”.

#### 4.9 Summary of Results

The sample group consisted of 29 male squash players with variable ages, height, weight, BMI and years playing squash. There was no association between winning status and taking part in the study.

There was no difference in age, BMI and years playing squash between those who won and those who lost in Round 1. The length of the matches and the RPE increased from Round 1 through to Round 3.

A significant correlation was found between number of Sources of Stress and the number of Symptoms of stress ( $r=0.419$ ,  $p=0.024$ ), although the correlation between the number of worse than normal Sources of stress and the number of worse than normal Symptoms of stress was not significant.

The symptoms section of the DALDA showed high internal consistency (Chronbach’s  $\alpha = 0.823$ ), that implied the items were measuring the same construct. The internal consistency of the sources of stress section was much lower (Chronbach’s  $\alpha = 0.531$ ). This alpha value increased to 0.60 with the removal of no item. However no particularly poor items were identified. The most frequently reported sources of stress

changed from one round to the next, with diet, training, sleep and recreation being most frequent in Round 1. In the next round, stress was reported to be due to social factors and climate. Muscle pains and unexplained aches were frequently reported symptoms, as were symptoms associated with mood, temper, irritability and arguments.

Although in every round the RPE of the winners was lower than the losers, the difference in ranking was only significant in Round 2 (Anova Chi sq.  $p = 0.01$ ) (Table 4-6). The tournament winner scored below the median of the other winners throughout, until the final round in which he reported almost maximal RPE.

## 5 Chapter 5: Discussion

### 5.1 Participants – demographic and sport related variables

The sample size of this study was 29 over four tournaments. Other studies have managed to attain approximately 10-12 participants which is comparable to the numbers attained in this study (50,59,67,68). Bias might have been introduced by the method of data collection in that more of the winners responded, however no association was found between participation and winning and there is no reason to believe that the sample was biased. However, the sample size was small and the results should not be seen as representative of all tournament players.

The age spread for this study was between 15 and 55 years with a mean of 27.6 years. This mean is comparable to several studies looking at squash players, Borg scale and performance testing literature where the participants ages ranged between 18 and 38 years old (3,4,18,23,40,56,59,62,64,76). The somewhat large spread of ages is likely due to the study looking at both elite as well as general competitive players competing in professional level tournaments.

The number of years participants had been playing squash in this study was between five and 35 years but this was not associated with first round winning or losing. This number was difficult to compare with the literature as the studies in general used the years participating in squash as an inclusion criteria and not as a possible testing variable (57,76). It appears that 10 to 15 years would be an average number of years in which to be reasonably proficient in playing squash at a competitive level and that coincides with the average age group of 19 to 29.

Most participants fell within the normal or healthy range of BMI (20-25) and no one fell into the obese category. BMI does have an inherent weakness in that it does not take into account a person's muscle mass or bone density which could therefore give a false positive for being overweight or obese (129).

The literature does show comparable values to other sporting codes but in general BMI was not assessed in other studies (130). The literature examines basic values of height and body mass (57,76).

These values were close to the values found in this study, which was 65-82 kg (3,4,45,48,56,76). Thus the validity of using the BMI in squash players seems acceptable, although, in other sports such as bodybuilding, the presence of excessive muscle bulk might invalidate the BMI categories.

### 5.2 Previous injuries

Although injury was not the main focus of this study, it was unexpected that there would be so few injuries during the tournament (only one). This was despite the high rate of previous injuries reported.

Unfortunately there were no articles in the literature, which looked at real time tournament injuries as part of their studies. In this study more than 90% of the participants stated that they had previously incurred an injury in the last five years, which prevented them from training and or participating in tournaments. This result however could pose a bias to the study as it has been noted that previous injury is a good predictor of having another or similar injury. Injuries in the amateur and beginner class of squash player are mainly found in the upper extremity and for the more accomplished player injuries occur in the lower extremities (1,96–98). As strength and power make up an important aspect of squash training it may be that the low percentage of injuries found in this study is related to the fact that players are significantly stronger than prior to their previous injury (2,78). This would make sense especially as core strength would make a major component of squash training due to the constant change of direction and extended lunges required (6,77,78). Also the increased strength and power would likely also have an additional increase in endurance which would therefore decrease the chance of incurring a repetitive injury while playing or training in squash (2,3,49,78). Whether or not the types of stress had any influence on the lack of injuries found during this tournament could not be tested. Finally the low percentage of injury may well be related to the participants not wanting to be seen by other competitors to be injured (i.e. not declaring a severe injury), and thus giving their potential opponents a mental advantage over them. This idea however needs to be tested further.

### 5.3 DALDA

The DALDA was used to assess the levels of stress the participants were experiencing during a tournament. In relation to other studies using the DALDA there was found to be no significant differences observed between part A of the DALDA. There were however differences found in the part B of the DALDA as was found in this study (11,33). It should be noted that with increased intensity of training there appears to be an increase in certain sources of stress, namely diet, sport, climate and health (37). The sources of stress most prevalent in this study were Sleep, Training/Exercise and Social/Work, which had the highest recording amongst the first round participants. The reported worse than normal sources of stress are due to the losing participants and those who reported the higher RPE during match play. The more accomplished players are more accustomed to hard training and thus not feeling the effects of said training when starting in the first round (3,4,45,48,57,76). Similarly in this study, in round two it was found that Social/Work and Sleep were the most reported worse than normal items by the participants. The reasons behind why these items were prevalent in the first and second rounds were due to aspects such as anxiety for the upcoming match or anxiety related to not being adequately prepared physically (23,25,38,111,131).

It is noted however that in relation to literature using the DALDA there were actually fewer worse than normal items present during match-play, which is interesting as, it suggests that for team sports there is less pressure and stress on the participants (37). It also suggests that in team sports interest, training effort and likeability are items that are positive sources of stress (37). This was not found in this study due to there being only two respondents in the final rounds.

Due to squash being an open skilled sport the pressures and stresses related to it are often of an external nature imposed on the player thus forcing them to adapt quickly and efficiently to perform (23,25,51,71). In several studies it was found that stress and how one copes with stress is an important factor on both performance as well as for potential injury (13,18,38,62).

Thus the literature has clearly shown that stress and coping appropriately to stress leads to both a physical as well as a mental/emotional toll on the athlete which over time can lead to a decreased resistance to stress as well as a performance deficit (8).

The important factor being that coping with any stress is often an emotional and mental process which manifests as physical symptoms depending on how effective the athletes coping strategies are (12,18,26). This is also true for tennis players as tennis is also considered to be an open skilled sport where circumstances within a match can change quickly and stress from external sources are prevalent (17,18,20,113). Lastly it should be noted that amount of stress and anxiety experienced by athletes who participate in an open skilled sport such as squash decreases the more accomplished or skilled the player is i.e. Novice players experience more stress and anxiety compared to highly skilled players (12,13,23,25,38,51).

Therefore in this study we found that the most prevalent symptoms in rounds one and two were muscle pains, irritability, unexplained aches, arguments, training effort, temper, tiredness, congestion, sore throat and lack of sleep. Thus those participants who experienced these symptoms of stress during the first and second round were the less skilled of the elite players who were possibly trying to improve their current standing on the squash professional circuit (3,23,25,45,49). The symptoms such as muscle pain are likely due to poor conditioning/tension/anxiety which resulted in the participant increasing their physical output or that the participants coping strategies were inadequate to overcome the match stress thus leading to a tensing of the body which in turn would decrease the quality of the players technique and in turn lead to a poor performance (21,25,67). The symptoms of temper and arguments were reasonably high in the first round and can be related to the emotional means by which those particular participants cope with stress (8,12,18,21,23).

As can be seen those values drop significantly in the second round which can suggest again that those players who did not have very good coping mechanisms for stress were eliminated from the tournament and thus had a poor performance, i.e. they lost their first round match.

There was no correlation between the number of worse than normal sources of stress and the number of worse than normal symptoms of stress.

It is interesting to note that all the symptoms of stress that were most prevalent in the first round increased in the second round.

The reason for this increase is suggested to be the natural decrease in participants as the rounds progressed as per the study protocol. Other possible reasons for this increase in the worse than normal stress symptoms is very likely due to the participants experiencing high levels of stress in their previous match which has translated into them having more symptoms of stress in the second round. The symptoms of stress related to immunity that increased were running nose and sore throat. Thus indicating that the physical and emotional stress is clearly affecting the participants' immunity to large degree as has been noted in other high intensity sports such as basketball, which has similarities to squash in its fitness requirements (33). However, more research is needed to investigate potential relationships between sources and symptoms of stress.

Another aspect that emerged was the positive effects of squash in that in many items the number reporting "better" increased while those reporting "worse" decreased when the number of sources of stress was low. While it is clear that the sources and symptoms of stress need to be addressed, the positive benefits of playing squash at this level also need to be recognised.

#### 5.4 RPE

It was suggested that RPE would increase incrementally as the participants progressed through the rounds of a tournament and this was the general trend. However, the greatest change in RPE was found between rounds one and two. This was found in the participants who were still relatively new to the sport, (i.e. less than seven years playing squash), as well as those who are attempting to step up in their squash development. The number of relatively low-ranked international and locally registered PSA players participating in these tournaments attests to this. RPE was found to be between 10 and 20 for the bulk of the participants in round 1. This was similar to round 2 with the RPE ranging from 12-20. RPE amongst the squash population was found to be similar compared to this study. Values of between 10-20 were generally observed in a consistent pattern as described in this study (3,42,82). These results can be related to other studies which have noted that squash players in general experience RPE in the range of 12-18 (3).



These RPE values are for training activity and not for during a tournament situation. However it was noted that squash players report higher RPE during training activities than during competitive matches (3,4).

### 5.5 Performance: Winners vs. Losers

Performance in many sports is an elusive concept and not easily described and addressing performance in squash becomes difficult, as there are several external as well as internal factors to consider. In general the literature has looked at performance in squash as completion of squash related tasks or physiological values e.g.  $VO_{2max}$ , number of court sprints per minute or how many forehand drives from the back of the court hit a particular zone (3–6,12,18,20,22,47,49,50,66,73,104,110, 124). Progression through the tournament was taken as a marker of performance in this study. Although it is a blunt instrument to measure the overall performance, it was considered sufficient, as the goal of any game sport is to win points, then games and ultimately the match (3,5,56,67,76). For this study we looked at the anthropometric and demographic factors affecting performance (Win/Loss performance) as well as the DALDA (Stress) and RPE.

Statistically it was found that age, BMI and the number of years playing squash did not have a significant influence over whether a participant won or lost. One reason for the lack of statistical difference could be that, as all were elite squash players, the variance in these factors was small as well as the actual sample size. In a group of recreational players, who might have a wider range of values, a difference might be detected. As these factors however were not linked in the literature to performance and were mainly used for descriptive purposes it was not possible to compare our results with published literature (4,25,38,45,50,67,97). Although not statistically different, the BMI of the bulk of the winners were within healthy ranges and the losing participants were represented more in the slightly overweight category for BMI. The lack of relationship found between BMI and Round 1 performance was not elucidated in this study. BMI has been shown to give higher values due to increased muscle bulk (128). In general squash players are quite lean and the winners in this study, visually had more muscle bulk when compared to losers, but this was not tested and could be investigated in the future.

These negative stress observations were seen mainly in the losing participants as shown in Figure 4-12: Distribution of participants Years playing vs. Win/Loss in Round 1 and Figure 4-13: Categorical Box-Whisker of Win/Loss vs. RPE in round 1. Likewise there was a correlation between the number of sources of stress and the number of symptoms of stress observed in participants.

This would suggest that stress certainly does have a role to play in the performance of squash players, particularly in the first few rounds of the tournament.

This is likely due to participants who are either new to the sport or those who are trying their best to improve and the opportunity to progress into the second round is an important progression. Those participants who are more accomplished do not suffer the same stress in the early rounds, which only increases towards the end of a tournament. The literature does make reference to various stresses i.e. physiological and psychological, related to competing in sport, which influence the performance of a squash player (2,3,17,19,23,25,27,38,44,95). Most notably the literature looks primarily at stress during competition and not specifically at the pre-stress levels of an athlete. Due to the multifaceted concept of stress it is difficult to model performance effectively in relation to stress (11,18,19,23,38,44). Understanding and processing the stressor quickly and effectively is the best means of coping with stress (12,17,19,38,44,84,85,95). It should be noted that in this study those participants that presented with more sources or symptoms of stress were more likely to lose their squash match. Thus stress is both a dynamic and repetitive factor that athletes need to adapt to and learn to address in order to perform at their best (12,18,19,27,38,84,95,116). The symptoms of stress, which were most evident in this study, were muscle pains, irritability, unexplained aches, arguments, training effort and temper. Muscle pains, aches and training effort can readily be addressed by correct physiotherapy intervention, and the irritability, arguments and temper can be addressed by using correct sports psychology techniques.

The RPE scale displayed a similar pattern to the DALDA when compared to winners and losers. The highest changes of RPE were found in participants in round 1 and 2 with the most significant differences in winners and losers being found in round 2.

A decreased RPE is associated with winning in the first two rounds of a tournament. Thus it was found that the less accomplished players i.e. match losers, were the ones that reported having a higher RPE.

Right up to the final round, the tournament winner reported less RPE than the median scores of the other winners. This would suggest that RPE for more accomplished players is only a significant factor in the end stages.

In summary, it may be that those that progress through the tournament do so, not only due to the superior skills levels which they presumably possess, but also because they are able to handle stress and fatigue better than the other players. It is not possible to say whether they win because of these factors or whether the stress and RPE is less because they are winning, but a clear relationship did emerge in this study.

## 5.6 Instrumentation

The RPE scale has been used in many studies and has been shown to be both reliable and valid in its usage (10,11,41,42,82,107). The Borg scale is a self-assessment scale, which is subjective but has a close correlation with several physiological markers (1,3,4,10,11,41,42,78,82,107). In regards to this study the reliability of the RPE was evident in that across all the tournaments that were tested, all the participants in the first round showed a similar pattern. The pattern being that the more accomplished and winning players reported a low value of their RPE. The converse was found across all tournaments for the less accomplished and losing players reported higher levels of RPE. The reliability of the RPE in this study was not easy to confirm, as  $\text{VO}_2\text{max}$  was not assessed in the participants. However it has been noted in other studies related to squash to have squash players reach levels of 80-85 % of their  $\text{VO}_2\text{max}$  compared to other racquet sports (49). Furthermore RPE of 15 -18 in squash players has been correlated with a  $\text{VO}_2$  of between 56 to 61 ml/min/kg (3). It can therefore be interpreted that the reported values of RPE in this study can give us an indication of the levels of  $\text{VO}_2$  that should be reached had we tested for  $\text{VO}_2$  max (3,4,45).

The DALDA is also a self-assessment instrument that has been shown to be both valid and reliable in assessing stress in athletes and thus assessing whether an athlete is overtraining (11,33,35–37,63).

This study did find that the DALDA was particularly effective in predicting which stress symptoms a participant were suffering from. The first section, which examines the sources of stress, had a lower Cronbach's Alpha than the second section, which relates to symptoms of stress. This implies that the internal consistency and reliability of the symptoms section is better than the sources section. Participants who reported a source of stress did not necessarily report more sources across the items. This was in contrast to the symptoms questionnaire, where those who reported some problem were more likely to report others across the board. Concurrent validity between the two sections of the questionnaire was demonstrated by the positive significant correlation between the number of sources and the number of symptoms.

It is recommended that the DALDA use more express terms, which are unambiguous to the participants using the tool. The terms used in the DALDA could have been clearer for those participants to understand what the questions were asking specifically. Although an information package was given to the participants in advance, there were still difficulties in understanding. These misunderstandings related to the questions in the DALDA were mainly directed at the fact that in the online survey participants were asked to answer according to the item being referred to. This required that participants answer with a specific understanding according to the recommendations by the DALDA use protocol (63). However it was found that all the participants were unclear on what exactly the item being surveyed referred to exactly.

This could have been due to the participants not reading the information package properly or further clarification regarding the items in the DALDA needs to be made. The difficulty seen in this study could be addressed in future studies with a short pre-tournament information discussion with all those participating players.

### 5.7 Limitations of this Study

This studies first limitation would be the short period in which the study was conducted. It is understood in order to model aspects of sport and performance a studies duration needs to be longer. The preferred duration would be to follow participants over a season or possibly two seasons of tournament participation. Unfortunately, the duration of the MPhil programme did not allow for an extended study period.

A better participant recruitment for this study would have been beneficial. This study was reliant on player understanding and interest in participating in this study. However when a player is on tour it is a reasonable assumption that players would prefer to focus on their own tournament progression rather than be distracted with taking part in a study.

The study instrumentation was useful, but the protocol and timing of administration could be adapted to get the greatest value. This can possibly be achieved using a specific time for all participants in which to do their relevant surveys so that it does not impact on any of their pre-match preparations as well as giving participants a 30 min breathing and stretch time post-match before completing the remaining surveys.

The lack of research assistance was a significant limitation of this study. This was noted especially when players were on different courts at the same time and it was difficult for one person to follow up with the various surveys.

A further limitation of this study was the use of a sample of convenience. This is due to the potential biases inherent in a sample of convenience. The first bias that presents with convenience sampling is that the participants are not representative of the overall population. Due to the willingness of the participants to participate there is an inherent probability that they will agree with various aspects of the study. Therefore possibly skewing the results towards a positive outcome. Furthermore drawing a conclusion in relation to the population may be difficult due to convenience sampling as well as the low sample size especially after round 2 (133,134).

The study's protocol in general was strong, but required some assistance in managing the numbers that could have been achieved for this study. Furthermore it is believed that with more personnel support, better recruitment would have been achieved. Although the drop out of this study was relatively low, having better support during the data collection phase can offset the rate of dropout.

## 6 Chapter 6: Summary and Conclusion

Squash is growing in popularity and it is an open skilled sport that requires a high physical as well as mental demand on an athlete's body.

Due to the lack of literature in general regarding squash, this study's aim was to examine potential relationships between stress, perceived exertion and performance. Based on the evidence provided in this dissertation, the study objectives as described in Aims and Objectives can be answered as follows:

- *To determine whether performance is associated with anthropometric and demographic data*

All anthropometric and demographic items assessed in this study showed no significant relationship to performance of elite professional squash players. It is concluded that these factors do not influence performance at this level, possibly due to the small variance in responses. The results are likely to be different if recreational players had been included in the study. The large proportion of participants who were in the healthy BMI range suggests the possible health benefits for the sport for young as well as the older participants. The benefits may be due to the full body effort required participating in squash.

- *To determine whether performance is associated with daily stress*

Daily stress was identified in squash players during this study. It is suggested that those participants who lost matches early on had the higher number of stresses. This is most evident in the first and second rounds of the tournaments.

The number of sources of stress then have little effect overall and it is actually the number of symptoms of stress that have a greater effect on the participants' performance. In the latter stages of the tournaments there seemed to be less symptoms of stress that participants experienced. However there were no specific sources or symptoms of stress that were found to be the most related to either poor or positive squash performances respectively.

- *To determine whether performance is associated with Borg scale of perceived exertion*

In this study, rate of perceived exertion showed the greatest changes related to performance were in round two of tournaments. This was a similar trend as described by the DALDA survey. This correlates with the participants who were generally knocked out of the tournament. However the converse is present when looking at the winner of the tournament who showed a low RPE in the first three rounds, which increased significantly as the final two rounds, approached as seen in figure 3-10. However, this increase of RPE in the last two rounds was not related to stress.

In conclusion, this study indicates that daily stress and perceived exertion do indeed have a relationship with performance, but only in the first and second rounds of tournaments.

## 7 Chapter 7: Recommendations

There are a number of sporting recommendations that have been highlighted and can be implemented. As the bulk of the significant changes related to the DALDA and RPE were found to be in the first two rounds it makes sense to target those players in the first and second round for specific stress management. The DALDA data showed that the number of sources of stress was not greatly influential to the athletes but the symptoms of stress were. The symptoms of stress that would need to be addressed when managing stress are muscle pains, irritability, unexplained aches, arguments, training effort and temper. All these symptoms can be managed through physiotherapy and sports psychology models of intervention.

Further research is required as to which models are the most effective to achieve maximum performance and to assess whether training models are effective in controlling for stress symptoms. In addition, this study was limited to elite players and further research should be undertaken to explore whether recreational players experience similar levels of stress, both in terms of the positive and negative effects of playing regularly.

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9.1 APPENDIX A: Human Research Ethic Committee Approval



UNIVERSITY OF CAPE TOWN  
Faculty of Health Sciences  
Human Research Ethics Committee



Room E52-24 Old Main Building  
Groote Schuur Hospital  
Observatory 7925  
Telephone [021] 406 6338 • Facsimile [021] 406 6411  
Email: [shuretta.thomas@uct.ac.za](mailto:shuretta.thomas@uct.ac.za)  
Website: [www.health.uct.ac.za/research/humanethics/forms](http://www.health.uct.ac.za/research/humanethics/forms)

25 April 2014

**HREC REF: 244/2014**

**Prof J Jelsma**  
Health & Rehab  
Occupational Therapy  
F45, OMB

Dear Prof Jelsma

**PROJECT TITLE: THE EFFECTS OF DAILY STRESS AND PERCEIVED EXERTION ON INJURY INCIDENCE AND PERFORMANCE IN COMPETITIVE SQUASH PLAYERS PARTICIPATING IN PROFESSIONAL SQUASH TOURNAMENTS (Masters MPHIL - M Montanus)**

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

**Approval is granted for one year until the 30<sup>th</sup> April 2015**

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

(Forms can be found on our website: [www.health.uct.ac.za/research/humanethics/forms](http://www.health.uct.ac.za/research/humanethics/forms))

***We acknowledge that the Masters student, Munro Montanus is also involved in this study.***

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC reference no in all your correspondence.

Yours sincerely

**PROFESSOR M BLOCKMAN**  
**CHAIRPERSON, FHS HUMAN ETHICS**

Federal Wide Assurance Number: FWA00001637.


Institutional Review Board (IRB) number: IRB00001938

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

HREC 244/2014

The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

HREC 244/2014

	<p><b>Department of Health and Rehabilitation Sciences</b></p> <p><b>Faculty of Health Sciences</b></p> <p>Divisions of Communications Sciences and Disorders, Nursing and Midwifery, Occupational Therapy, Physiotherapy</p> <p>F45 Old Main Building, Groote Schuur Hospital, Observatory 7925</p> <p>Tel: +27 (0) 21 406 6401 Fax: +27 (0) 21 406 6323</p> <p>Internet: <a href="http://www.uct.ac.za">www.uct.ac.za</a></p>
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THE RELATIONSHIP BETWEEN PERFORMANCE (TOURNAMENT PROGRESSION), DAILY STRESS AND PERCEIVED EXERTION IN PARTICIPANTS OF PROFESSIONAL SQUASH TOURNAMENTS.

To the Tournament director:

**RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH UTILISING THE PARTICIPANTS OF THE TOURNAMENT.**

I am a Master of Philosophy Sports Physiotherapy student, currently studying through the University of Cape Town, Division of Physiotherapy. As part of my degree programme, I am required to complete a dissertation in a chosen area. I have chosen a study, which is focusing on squash players. My aim is to evaluate whether there is any association between daily stress, perceived exertion and injury incidence and performance during a professional tournament.

Ethical approval has been granted by the Human Research and Ethics Committee, faculty of Health Sciences, University of Cape Town.

Due to the limited research available on performance and injury incidence in squash generally as well as in the South African context, my study aims to add positively to the overall knowledge base relating to squash. This will hopefully allow for better physical training and mental training strategies to be developed as well as to grow the injury incidence library and map potential causal factors for injury. In order to proceed with my study I require volunteers to participate.

I would therefore like to request that an email be sent on behalf of UCT and myself via the tournament director to all participants a week in advance of the tournament commencement stating that all participants will have an opportunity to participate in this study should they decide to take part. An attachment describing in brief the process of the study will be forwarded with the email thus giving players the opportunity to decide.

Should players decide to participate they will then be required to complete a consent form on the day of registration. The survey will be administered via mobile phone using the Magpi survey application. Complete anonymity will not be possible but all personal details and relevant information of the participant will be held in strictest confidentiality.

The study is a non-intervention study and is basically a data collection exercise. Once the participants' tournament has started they will be required to fill out a Daily Analysis of Life Demands for Athletes (DALDA), two hours before their allocated match. A secondary survey will also be administered directly after their match, which will assess the Rated Perceived Exertion of the player during the match. All surveys will have an online link for players to access quickly and easily. Should the player have injured himself during the match, the nature and extent of the injury will be noted using the Magpi survey application. There is therefore no risk associated with the study. However the nature of squash does place the participants at risk of injury and there will be a specific protocol for all participants to follow should they get injured or if the psychometric component reveals any adverse events.

Potential benefits:

All participants will be given a detailed breakdown of the results which will be made available in a easy to use handout which should be able to guide all players if their daily stress and training loads need to be modified so as to potentially prevent injury and also improve performance. The overall result of the study will be made available to all participants and can be distributed to the PSA and all provincial squash associations on request.

Questions and queries:

Should any participant, sponsors or other directors require any further information about the study, feel free to contact my supervisors or myself. Find details below.

Researcher:                      Munro Montanus                                      [munro.montanus@gmail.com](mailto:munro.montanus@gmail.com)

Supervisor:                      Professor Jennifer Jelsma                                      [jennifer.jelsma@uct.ac.za](mailto:jennifer.jelsma@uct.ac.za)

Co-Supervisor: Dr. Theresa Burgess                                      [theresa.burgess@uct.ac.za](mailto:theresa.burgess@uct.ac.za)

Should you have any further queries or concerns about the ethics related to this study you are more than welcome to contact the Human Research and Ethics Committee Chair, Professor Marc Blockman.

Faculty of Health Sciences Human Research and Ethics Committee:

Chair: Professor Marc Blockman                                      Tel: +27 21 406 6492

Thank you for your assistance in this regard and also for your support in research in this field.

I look forward to a positive response.

Kind regards

Munro Montanus

B.Sc. (Physiotherapy) (UCT)

### 9.3 APPENDIX C: Information Letter



#### **Department of Health and Rehabilitation Sciences**

#### **Faculty of Health Sciences**

Divisions of Communications Sciences and Disorders,  
Nursing and Midwifery, Occupational Therapy, Physiotherapy

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#### **MPhil. Sports Physiotherapy Study:**



THE RELATIONSHIP BETWEEN PERFORMANCE (TOURNAMENT PROGRESSION), DAILY STRESS AND PERCEIVED EXERTION IN PARTICIPANTS OF PROFESIONAL SQUASH TOURNAMENTS.

**INFORMATION LETTER**

Dear Participant

I am a Masters in Sports Physiotherapy student from the University of Cape Town, Physiotherapy Division. I will be conducting a study, which will be assessing whether there is any association or relationship between performance outcome and the following variables: Daily stress, perceived exertion, and injury incidence in competitive squash players participating in professional squash tournaments. The study will be a non-intervention study and will therefore place no physical risk to any participants.

Due to the fact that there is limited literature about squash, squash related injuries and performance outcomes, this study will add significantly to the base knowledge currently available here in South Africa as well as abroad.

This study has been granted Ethics approval through the Human Research Ethics Committee, faculty of Health Sciences, University of Cape Town and will be supervised by Professor Jennifer Jelsma and Dr. Theresa Burgess.

All prospective participants will be required to complete a consent form before commencement of the study. This will take place on the day of registration for the respective tournament. The Magpi survey application will be used to administer the surveys. The surveys will be available via mobile phone for ease of use. A pre-tournament injury survey will be completed on the first day of the tournament. Participating players will be required to complete a survey, which includes the Daily Analysis of Life Demands for Athletes survey two hours before their match, and also a Rated Perceived Exertion survey immediately after their match. Should an injury occur a third survey detailing the injury is to be completed. Participants that win their fixture will continue to take the DALDA and RPE surveys two hours before their next match and immediately after the

fixture. Those players that do not win their fixture are not required to continue filling out surveys. All surveys will be easily accessible via mobile phone. All the surveys will be streamlined for quick and easy use. Facilities will be made available for players to access the survey site for ease of completing surveys.

#### BENEFITS:

This study is to be a non-intervention study, however due to the nature of the sport there is a risk of injury during play. Should participants get injured then they are required to contact the study investigator or tournament director who will then refer the participant to the necessary medical practitioner for assessment and treatment. Should there be any adverse event that is brought to the investigators attention through the psychometric test that is to be self-administered, the participant will be contacted directly by the investigator and will be given recommendations and referral information for relevant medical practitioners to get adequate assistance.

By participating in this study you will be given a comprehensive breakdown of the results of the study, which will give an indication as to what variables affect performance outcome. This will in turn potentially give an indication as to where physical and mental training should be focused towards in order to improve and become a better squash player. Further benefits of this study are a description of the most common injuries presenting in squash players, which would potentially give information as to where training can be modified to prevent certain injuries.

Reporting of the study will be done in such a way as to not disclose any personal information of any of the participants. However it would still potentially be possible to work out the participants of the study from the tournament results which are freely available on the PSA website. Information related to results of the surveys would not be able to be related to specific individuals except for the overall winner of the tournament.

#### QUESTIONS AND CONCERNS:

Should any participant have any questions or concerns about the study, and/or your rights and welfare as a participant, please contact the following persons and we will get back to you as soon as possible. Please also note that all enquiries will be held in utmost confidence.

Munro Montanus

Cell: 083 691 0963

Email: [munro.montanus@gmail.com](mailto:munro.montanus@gmail.com)

Professor Jennifer Jelsma

Tel: +27 21 406 6595

Email: [jennifer.jelsma@uct.ac.za](mailto:jennifer.jelsma@uct.ac.za)

Dr. Theresa Burgess

Tel: +27 21 406 6171

Email: [theresa.burgess@uct.ac.za](mailto:theresa.burgess@uct.ac.za)

Professor Marc Blockman (Chairperson of the Human Research Ethics Committee)

Tel: +27 21 406 6492

	<b>Department of Health and Rehabilitation Sciences</b>
	<b>Faculty of Health Sciences</b>
	Divisions of Communications Sciences and Disorders, Nursing and Midwifery, Occupational Therapy, Physiotherapy
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**CONSENT FORM FOR PARTICIPATION IN RESEARCH STUDY:**

**THE RELATIONSHIP BETWEEN PERFORMANCE (TOURNAMENT PROGRESSION), DAILY STRESS AND PERCEIVED EXERTION IN PARTICIPANTS OF PROFESIONAL SQUASH TOURNAMENTS.**

I (Name) \_\_\_\_\_ am confirming that I have read and understood the information presented and that I am willing to participate in this study. I hereby also confirm that my current international PSA ranking or national ranking (for unregistered SA players) is \_\_\_\_\_.

As a participant in this study I am given the right to withdraw from the study at any time and also have opportunity to ask any questions throughout the study.

All information will be kept confidential and no participant will be named in the event of publication.

_____	_____	_____
SIGNATURE OF PARTICIPANT	NAME (PRINT PLEASE)	DATE

_____	_____	_____
SIGNATURE OF INVESTIGATOR	NAME (PRINT PLEASE)	DATE

Thank you for your interest and support of sport physiotherapy research.

Kind regards

Munro Montanus

BSc. (Physiotherapy) (UCT)

A) ANTHROPOMETRIC DATA

NAME:

DOB (DD/MM/YYYY):

AGE (Yrs.):

HEIGHT (cm):

WEIGHT (kg):

BMI [WEIGHT/(HEIGHT)<sup>2</sup> :

B) SQUASH HISTORY:

1) What is your current international rank?

2) How long have you been playing squash? Years

3) What hand do you play squash with (L/R)?

C) INJURY HISTORY:

☐ Y☐ N

1) Have you been injured due to squash or related activities?

- If yes please add further details below:

Year	When did injury occur: COMPETITION/PRACTICE?	Area of injury?	Treatment: Y/N	Type of treatment: Surgery, Physio, etc.

## INJURY SURVEILLANCE:

1) Did an injury occur this week (Circle one): If Yes then continue with items below.	1) Yes, 2) No
2) Date of Injury (dd/mm/yyyy)	
3) Injury occurred when (Circle one):	1) Competition, 2) Training
4) Injury Involved (Circle one):	1) Contact with opponent 2) Contact with playing surface 3) Contact with racquet or ball 4) No apparent contact (rotation about planted foot) 5) No apparent contact (Other) 6) Other
5) Principal body part injured (circle one):	1) Head 2) Eye 3) Nose, 4) Mouth 5) Neck 6) Shoulder 7) Upper arm 8) Elbow 9) Forearm



	10) Wrist, 11) Hand  12) Lower Back  13) Pelvis/Hips/Groin  14) Upper leg, 15) Knee  16) Lower leg  17) Ankle  18) Achilles Tendon  19) Foot  20) Other
6) Primary type of injury (Circle one):	1) Abrasion  2) Contusion  3) Laceration  4) Bursitis  5) Tendonitis  6) Ligament sprain (incomplete tear)  7) Ligament sprain (complete tear)  8) Muscle tendon strain (incomplete tear)  9) Muscle tendon strain (complete tear)
7) This injury is a (Circle one):	1) New injury  2) Recurrence of injury from this

	<p>season</p> <p>3) Recurrence of injury from previous season</p> <p>4) Complication of previous injury (this sport)</p> <p>5) Complication of previous injury (other sport)</p> <p>6) Recurrence of non-sport injury</p> <p>7) Complication of other sport injury</p>
8) Injury assessment (Circle one):	<p>1) Clinical exam by physiotherapist</p> <p>2) Clinical exam by Physician</p> <p>3) X-ray</p> <p>4) MRI</p> <p>5) Other imaging</p> <p>6) Surgery</p> <p>7) Blood work</p> <p>8) Other</p>
9) Time off from training/playing (Choose one)	<p>1) No time off</p> <p>2) 1 week</p> <p>3) 2 weeks</p> <p>4) 1 month</p> <p>5) 2 months</p> <p>6) 3 months</p> <p>7) 6 months</p>

	8) 1 yr.
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**DALDA**

Date 03/05/2011

**DALDA Stress Sources - Part A**

	worse than normal	normal	better than normal
⚠ Diet	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Home-Life	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ School/College/Work	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Friends	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Training and Exercise	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Climate	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Sleep	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Recreation	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Health	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

**DALDA Stress Sources - Part B**

	worse than normal	normal	better than normal
⚠ Muscle Pains	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Techniques	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Tiredness	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Need for a rest	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Supplementary Work	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Boredom	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Recovery Time	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Irritability	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Weight	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Throat	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Internal	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Unexplained Aches	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Technique Power	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Enough Sleep	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Between sessions recovery	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ General Weakness	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Interest	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Arguments	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Skin Rashes	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Congestion	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Training Effort	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Temper	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Swellings	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Likeability	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
⚠ Running Nose	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

Ok
Cancel

## 9.8 APPENDIX H: Rated Perceived Exertion (RPE) – Borg Scale

### HOW TO USE THE SCALE:

- While playing squash, think about your overall feelings of physical stress, effort and fatigue. Do not concern yourself with any single thing, like leg pain or shortness of breath. Try to concentrate on your total, inner feeling of exertion.
- Find the best description of your level of effort from the examples on the right side of the table.
- Find the number rating that matches that description.

<b>6</b>	<b>No exertion</b>
<b>7</b>	
<b>8</b>	
<b>9</b>	
<b>10</b>	
<b>11</b>	<b>Light</b>
<b>12</b>	
<b>13</b>	<b>Somewhat hard</b>
<b>14</b>	
<b>15</b>	<b>Hard (heavy)</b>
<b>16</b>	
<b>17</b>	<b>Very hard</b>
<b>18</b>	
<b>19</b>	
<b>20</b>	<b>Maximal exertion</b>